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ORGANIZATION OF THE FIELD ARTILLERY.

The recent re-organization of our artillery has undoubtedly greatly improved its previous status, and in most respects is all that at present can be desired for the coast artillery, but as for the field artillery this is very far from being the fact.

As matters now stand we have, after so many years of effort, reached the conditions under which the British Royal Artillery has with so little success struggled to attain efficiency for war, as a huge aggregation of more than two hundred batteries, comprising both coast and field artillery. One great advantage claimed, and until within the last few years realized in the Royal Artillery, was the fact that it permitted the selection and assignment of officers to the field and coast artillery according to the peculiar fitness of individuals, especially as applied to the former, in which youth and physical qualities are so necessary to insure efficiency.

So long as artillery organization, instruction, material, etc., were simple, as they undoubtedly were only a few years ago compared with present conditions, the transfer of officers from one of these branches of the service to the other was a matter of not very serious moment. But now a great change has taken place, and it has been thoroughly demonstrated that under present conditions, it requires a lifetime of service in any one of several important subdivisions of artillery services in order to become thoroughly proficient therein. So evident has this become that for several years past, artillery authorities of the Royal Artillery have strenuously endeavored to secure a complete separation of the coast from the field artillery.

One of the chief reasons for this separation is found in the fact that the younger officers who have enough influence at court to secure service in the field artillery (to them by far the most desirable), after they take on years and weight, lose interest, and their influence secures a transfer to the coast artillery. Though he may have been an excellent field artillery officer in every respect, it is now found that very few indeed of the necessary accomplishments of this branch of the service find any useful application in the service of coast artillery, and his usefulness therein is practically *nil.* He is now too old to begin the study and practice of his new profession even if so disposed, for it is a new one in almost every essential.

This system is found to be not only absurd but extremely vicious, altogether aside from the fact that the Regiment as a unit is "milked" for the benefit of the field artillery, to the very serious detriment of the coast artillery, and the service in general. As a principle, as well might a doctor of divinity after years devoted to its study, give up his his specialty for that of law. Had it not been for the obstinate and often vicious conservatism so characteristic of the English military folk, but more especially the glorious record of this great Royal Regiment of artillery, the coast would long ago have been separated from the field artillery. Even now such an event would quickly take place, could each fraction take with it the grand history of the old Regiment as its own. Our Artillery Corps has yet to realize for itself a proud record, and there is not the same grave obstacle to prevent the two branches of the service from being separated, leaving the field artillery to make for itself its own history, as do the cavalry and infantry.

The evils of such an organization were long since detected in every one of the continental armies and corrected by the complete separation of the branches of the artillery service.

Coast artillery is maintained, organized, and instructed for purposes wholly disconnected from those pertaining to field artillery, and by means of an armament and appliances even more divergent, nor has it any more connection with any other part of a field army, while it is evident that field artillery is as essentially a fundamental part of such an army as is either the cavalry or infantry, and in fact has no more connection with the coast artillery than has either of these. If field artillery has been properly organized and trained, it cannot be made to do the work of the other, without its special organization and training, any more readily than the cavalry or infantry; neither can possibly be depended upon to do the highly specialized work of the other. Yet it is sought to be in a position in case of emergency to transfer say a battery of coast artillery to the field. As a matter of fact it would be very much wiser and better in every way to convert a troop of cavalry into a field battery, as the cavalryman would at least have a knowledge of the uses and care of horses so essential in the field artillery, which the coast artilleryman would not have.

These, and many other facts quite as pertinent, and the rules of action predicated thereon, obtain absolutely in every military nation, as they must in our own, but apparently do so only in theory, as evinced by the organization for field artillery as prescribed in the authorized regulations as compared with what actually exists. For instance in those for infantry; article 460. The brigade consists of three regiments, or a greater or less number. 479. The division consists of three brigades of infantry and two or more batteries of artillery, or a greater or less number. 484. The corps consists of three divisions, one or more regiments of cavalry, and the corps artillery, which is an addition to the divisional artillery.

From the cavalry regulations; Article 921. The brigade consists of three regiments. An independent brigade should consist of at least three regiments and a battery of horse artillery. 941. The division consists of three brigades of cavalry and two or more horse batteries. 947. The corps consists of two or more divisions of cavalry. 949. One or more regiments of cavalry, called *corps cavalry*, are attached to each corps of infantry.

The light artillery regulations prescribe; Article 986. Light and heavy batteries, the former including horse batteries. 992. The divisional artillery comprises a battalion of from two to four batteries. 993. The corps artillery two or more battalions of field and horse batteries in suitable proportions. 995. A battalion of horse artillery is attached to and is a part of a cavalry division. 996. The proportion of light artillery is from three to four guns to one thousand men.

The heavy artillery regulations; Article 5. Siege artillery is used in the attack of places, and, it accompanies armies in the field operations, is mounted upon carriages, which serve for its transportation. It is also employed in the defense of field works. It is sometimes called Garrison Artillery. 662. No specific rules can be laid down regarding the amount of artillery required for siege operations. The most remarkable sieges that have taken place since the introduction of the present style of artillery and small-arms have employed about 6,500 fighting men per mile of investment, with 5 pieces per thousand men, or 33 per mile.

From all of which it is quite evident that the strength and organizations of field artillery is predicated solely upon those the cavalry and infantry of any given army, without any connection whatever with the coast artillery, nor is anything of the kind even contemplated by the supreme authorities in our army, who make the regulations for the government thereof. But, as in the Royal regiment of Artillery, it remains for artillery officers alone to try to continue the combination of the coast with the field artillery, but in our service at least, probably for the very good reason that it was found far better to first take a half a loaf, rather than get no bread; then fight for the other half.

Based upon the conditions as set forth in the regulations, it becomes necessary to determine how much and what kind of field artillery is required to fulfill these conditions, having a force of fifteen regiments of cavalry and thirty of infantry in the army.

If we apply the regulations for the infantry we will have for a brigade of three regiments 5400 muskets, for a division 16,200, for an army corps of two divisions 32,400, or one of three divisions 48,600 muskets. In the first case the corps requires 18 regiments, wiih not enough left for a second corps, and in the second case the corps requires all of the regiments in the army but three. Either is absurd on its face, for the reason that when the regulation was made the regiment had a war strength of only a thousand muskets.

Generals Grant, Sherman and others of our best and most experienced officers have left testimony to the effect that 20,000 muskets is the muximum allowable for an army corps in our service, even with good troops, as good corps commanders were not always to be had, even after we had been engaged in one of the greatest wars of any age for three years or more, and when, though the men were not strictly regular soldiers, they were certainly war-seasoned veterans, such as are seldom to be found in any army.

What the organizations for cavalry and infantry will be is of cource for the army commanders and the officers of those arms of the service to determine. But under present conditions they can be stated with reasonable certainty.

A brigade of volunteers seems to have been limited to about four thousand men, three regiments before the re-organization, 4068 muskets, during the recent war with Spain, and the Congress provided for one brigadier general for each four thousand men. On a war footing a brigade in European armies generally consists of two regiments, about 6000 men. Three of the present regiments will give 5400 muskets, a strong brigade of regulars when it is remembered that the nominal strength must be increased on hundred and thirty per cent., with raw recruits. Two brigades, 10,800 muskets, will give a strong division, and two divisions a corps of 21,600 muskets. To this corps must be added one or more regiments of corps cavalry, the divisional and corps artillery with their ammunition trains, the engineers, signal, medical, the supply departments, etc., which will add to the personel of the corps about forty-five per cent., of above strength, giving a total of 31,300 for an Army Corps.

For the cavalry we can probably accept three regiments for the separate brigade as prescribed in the regulations, although 3600 sabers look much like a European division. A german cavalry regiment consists of five spuadrons of two troops each. One of these squadrons remains at the depot, upon mobilazation giving up the necessary men and horses to complete the war strength of the regiment of four squadrons which takes the field with a strength of only 592 sabers, and a brigade of four regiments only 2368. It must be carefully and constantly remembered that our fifteen regiments of cavalry are the equivalent of thirty regiments in European armies generally as they appear in the field on a war footing. In other words what is called a squadron in our service (4 troops of 100 sabers each), is the equivalent of two-thirds of an entire regiment of cavalry in continental services, and that instead of having only fifteen regiments, we have practically forty-five handy littles one. Each one of our enormous and unwieldy regiments being to all intents and purposes a brigade. Herein lies the secret as to why our cavalry officers have so long to wait for reasonable promotion. If the present regiments were organized as in Europe, matters would be very different indeed. A brigade of two of our regiments will give thirty-two sabers more than one of four German regiments.

If we put three brigades of three regiments each into a division, we at once dispose of nine of our fifteen cavalry regiments. With two regiments to a brigade, and two of the later to a division we shall have 7200 sabers, 14,000 men and horses, and the division commander has a vastly more difficult command in every respect than has his brother of the infantry with 10,800 men only, for the fact must constrntly be kept in mind to insure success in war especially in field artillery and cavalry, the horse is of quite as much, and very often of much more importance than the man who rides him, at the same time he is more troublsome to care for than the man.

Such an organization will give two strong divisions with three regiments to spare, two at least of which will be required for the corps cavalry of the infantry corps. With two divisions to a corps we shall have a cavalry corps of 14,400 sabers, 28,800 men and horses. If a cavalry division can be assigned to each of the two infantry army corps, otherwise a cavalry division for each flank of the army, or for any other possible disposition.

For the infantry the regulations prescribe two to four batteries as the divisional artillery. The number is of course controlled by the conditions as to the character of the troops, nature of the field of operation, etc., but more absolutely by the number and power of the enemy's guns. Although, as has already appeared, the officers, non-commissioned officers and some of the men will be disciplined and seasoned soldiers, nearly two-thirds will be simply raw recruits in the event of war, calling for a larger proportion of artillery irrespective ot any other condition. But to keep entirely within limits, suppose we take the mean of the regulations as most likely to meet average conditions, three batteries to a division of infantry. Then for the divisional artillery of a corps we will have a regiment of light field artillery of two battalions (if there be three divisions to an army corps, there would be three batteries of artillery to the regiment of course), each of four batteries; the fourth of each battalion comprising the personel of the divisional artillery ammunition trains, and only to be organized in case of emergency. For the corps artillery there will be required a like regiment of heavy field artillery, and at least one battalion of horse artillery. Some of our officers have commented adversely upon the 3.60 heavy field gun as the arm for the corps artillery, not because of its want of power of fire, but because of its weight, which is about 2450 pounds for the gun and carriage. It might be well to call attention to the fact that the old 12-pounder of the war of 1861-5, weighed about the same or even a little less, and that it was used by several batteries of *horse* artillery serving with cavalry throughout the war and no complaint was made on account of the cannoneers being overworked or exhausted by reason of its weight. It is possible that there were giants in those days, but not probable, and we can handle in the slower going heavy field batteries the weight that could not in anywise stop the dashing horse artilleryman. The batteries of the regiment of heavy field artillery should be equipped with the 3.60 or a more modern and powerful gun of similar weight.

The two battalions of horse artillery of the two corps artilleries will constitute a regiment of horse artillery, organized precisely as is the regiment which serves with the cavalry. Whether its battalions should be attached to the corps directly, or held by the army commander as an army reserve, is a question to be decided by him or his chief of artillery. The "doctors differ" somewhat as to which plan should obtain, with the further complication that some of them hold that both sides are right, which would call for more horse artillery for the army reserve, it being conceeded by all that the corps cannot be deprived of what it has. If this view obtains we shall require a regiment of horse artillery for the infantry over and above what is here contemplated, but as the regulations apparently do not comtemplate an army reserve, it need not be considered here, further than to call attention to the fact that the organization here presented gives 4⅙ guns per 1000 muskets in an army corps, whereas in a German army corps for instance, this proportion of guns is from 5 to 5½, according to the organization of the corps, which differs in several cases. With the additional regiment for the army reserve above indicated, we would have exactly 5 guns per 1000 muskets in a field army, which looks very much as if it was required, whether to go to the corps artillery or to the army reserve.

For the cavalry organization the regulations prescribe that a division consists of three brigades and two or more batteries of horse artillery. A battalion of horse artillery as above described fits in here exactly, giving a battery to each brigade in case they have to operate separately, a not unfrequent occurrence, the two battalions forming a regiment of horse artillery for the cavalry corps, with which no corps artillery is contemplated or desirable, giving 2½ guns per thousand sabers.

To complete the complement of an army it is necessary to add siege artillery. Here we have to deal with a very indefinite problem as to the number and kinds of batteries, battalions or regiments. But that this arm should at least find representation in our army is beyond question of doubt, for a model and school of instruction in time of peace, if for no other. A regiment of siege artillery should consist of three battalions of four batteries each, a fifth battery to be added to each battalion for ammunition trains at the discretion of the President in case of emergency. In time of peace but two battalions of three batteries each to be authorized, the third battalion to be added only in case of emergency. This will make the organization of all the regiments uniform on a peace footing, but enabling the proper and necessary changes to readily be made in the event of war.

The artillery regulations classify mountain artillery, but make no provisions therefor. This was before our late war. It has been found in Cuba and the Philippines to be the only kind of field artillery capable of rendering efficient and valuable services at the proper time and place,.and especially without proving a hindrance rather than an aid to the other arms. It can, when properly equipped go anywhere where the foot of the infantryman or the horse of the trooper can carry them, always on time and without any aid. It was and is badly needed for active service now, and to a much greater degree than its present very restricted force permits. Its existance as an integral factor in our field artillery organization is as necessary as for any other kind, and its existence as a branch of the field artillery is especially provided for in the present re-organization law in terms * * * "the field artillery as that portion (of the artillery corps) accompanying an army in the field, including field and light artillery proper, horse artillery, siege artillery, mountain artillery, and also machine gun batteries." A regiment of mountain artillery should be organized the same as for the horse artillery, provisions being made that the cannoneers may be mounted the same as in that arm, when batteries are to serve with the cavalry, which surely will be the case. As to armament, there are many models of modern mountain guns of long range and greater power than was the rifle field gun of but a few years ago. By utalizing the screw-joint principle of construction as in the Royal Artillery, a very much more powerful gun can readily be secured than any now in existence. (See *Journal of the United States Artillery*, March-April 1898, Vol. 9, No. 2.)

As heretofore indicated the two army corps of infantry and one of cavalry require three regiments of horse, two of light, and two of heavy field artillery as the necessary complement of field artillery for the army in the field in war, which, with the regiment of siege artillery, makes eight regiments in all. As there is a question as to the regiment of horse artillery for an army reserve, we can perhaps do far better by substituting for it the regiment of mountain artillery, the necessity for which cannot be questioned.

As for the machine-gun batteries authorized by law, artillery authorities do not consider as a "field gun" anything in the shape of a gun unless it be capable of firing a projectile with a time fuze, and no artillery service includes such batteries in regular field artillery organization.

We already have thirty field batteries provided to our hand with which to organize five regiments immediately, of the remain ing three, one can be added on the first of July in each succeeding year, or sooner in the discretion of the President.

That the field artillery of the army hereafter shall consist of two regiments of horse artillery, two regiments of light and two of heavy field artillery, one regiment of mountain artillery, and one regiment of siege artillery. That the thirty batteries of field artillery now authorized by law for the Artillery Corps are hereby detached therefrom and shall be by the President organized by him into five of the regiments hereinbefore authorized, that he shall on the first day of July in each succeeding three years cause to be organized one additional regiment of field artillery as herein prescribed. That the President may select the field officers of the five regiments first organized, and promote them from the next lower grades in the Artillery Corps, and may select the captains and lieutenants from like grades in that corps and assign them to the field artillery, second lieutenants of cavalry may be transfered to the field artillery. As additional regiments are organized promotion to them shall be made by seniority in the field artillery as now provided by law. Provided that the carrying out of the provisions of this act shall not thereby reduce the number of batteries now prescribed by law for the Artillery Corps the places of the field batteries being taken by coast artillery batteries, nor shall it decrease the number or grade of the officers of that corps.

A regiment of field artillery should consist of one colonel, one adjutant, one quartermaster and commissary, one veterinarian with the pay and allowances of a captain mounted, one sergeant major, one quartermaster sergeant, one commissary sergeant, one saddler sergeant, one farrier sergeant, two color sergeants, one chief trumpeter, a band as now authorized by law for a regiment of cavalry, and two battalions. The regimental adjutants and quartermasters to be extra captains selected from the captains of their respective regiments. A battalion of field artillery should consist of one lieutenant-colonel, one major, one battalion adjutant, one battalion quartermaster and commissary, one veterinarian, one battalion sergeant major, one battalion quartermaster sergeant, one battalion commissary sergeant, one battalion saddler sergeant, one battalion farrier sergeant, one corporal battalion standard bearer, one trumpeter, and three field batteries organized as now prescribed by law, the battalion adjutants and quartermasters to be extra first lieutenant selected from the first lieutenants of their respective battalions. Of the battalion veterinarians, the senior half to receive the pay and allowances of a first lieutenant mounted and the juniors the pay and allowances of a second lieutenant mounted. All officers and enlisted men of the field artillery regiments to receive the pay and allowances now provided by law for those of like grades in the cavalry. The President when he may deem it necessary, may add to the above regimental organization, for the regiment of siege artillery one battalion, and to each of the battalions of the horse and mountain artillery regiments one battery to be equipped for service as field artillery ammunition trains, and to each of the battalion organizations including the third battalion of the siege artillery regiment, of the light, heavy and siege artillery regiments two batteries one of which shall be equipped for services as field artillery ammunition trains. That the President in his discretion may add one second lieutenant to each battery of the field artillery and he may add four veternarians of the senior and four of the junior grade to the field artillery for service with the ammunition trains and at the artillery depot.

This will leave the artillery corps with the same number of batteries it now has, all of the coast artillery. All of which are even now absolutely required to even inadiquately man and care for the vast armament completed and mounted or awaiting to be mounted. Long before that corps is completely organized it will be, even with this addition, short handed both for officers and men.

In time of peace these regiments are apparently small as to number of batteries and men, and should be so on account of the cost of maintainance. But in war the colonel will have in a horse artillery regiment (not counting the battery of the train) 1072 enlisted men, 1224 horses, a total of 2296 men and horses, to say nothing of 36 guns, etc. A light or heavy field regiment will have (not counting train) 1300 enlisted, 1152 horses, a total of 2452 men and horses, 48 guns, with their material. A battalion of three of the regiments will have, respectively, 525 enlisted, 612 horses, 1152 men and horses and 18 guns for horse; and 706 enlisted, 612 horses, 1282 men and horses, 24 guns for the other regiments. In either case we have a battalion which, for size, importance, difficulty and intricacy of command, administration and instruction is fully the peer of an entire infantry regiment with its five field officers, and chiefly for this reason it should be and is proposed to be placed under the command of a lieutenant-colonel, who is given the necessary staff for the tactical purposes of the unit, and to a limited extent of administration also, as this is much more liable to be called upon to act alone in ours, than in foreign services. Aside from the necessity, a lieutenant-colonel is unquestionably the proper battalion commander, and is so in fact generally in all armies save our own.

During the Revolution we took the English ten company battalion (two or more constituting an English regiment, a colonel there was, of course, a prince of the blood in those days being half a dozen of him, but for revenue only), commanded by a lieutenant-colonel, called it a "regiment," giving to it the proper regimental commander, a colonel, the battalion organization otherwise remaining practically the same. This of course reduced the lieutenant-colonel to be a fifth wheel to this military wagon, a position he holds to this day in our service, for if a major is the proper battalion commander, there is no military reason at all for the existence of a lieutenant colonel. If ignorance of military usages and laws of command did not indicate a proper military hierarchy, etymology should have done so very clearly, for a "lieutenant" holds the place, in this case of that of the colonel, authorized to act for him directly in case of absence, vested with his right to command under certain circumstances, while a "major" is simply superior to some one else, and is not and never was, properly speaking a "commanding officer," but only an over officer to aid his superior in the proper execution of his duties in camp, on the march and on the battlefield, duties which it was found captains could not be expected to perform, having their own commands to look after.

The lieutenant-colonel commanding a battalion of field artillery will also be the chief of artillery for the division to which he is attached, charged with the executive and administrative duties incident thereto, as well as the onerous tactical duties. When the division commander seeks to establish his position in battle, he takes his chief of artillery with him as his principle staff officer, to determine the artillery position, and then to get his guns into position.

To insure the youth and physical vigor so essential to efficient service in the field, it will not only be necessary to select officers for the field artillery with this end in view at the start, but also to make such provisions of law that those on active duty shall continue to be of suitable age in their respective grades. This will be necessary for the reason that the number of field officers is so small in proportion to the number of subalterns, that promotion must inevitably be blocked. It will be necessary to select all of the field officers and possibly some of the captains from the next lower grades in the Artillery Corps, to insure proper ages to start with. The limit of retiring age in the mounted services should be sixty years, and this limit should be fixed at once. As this latter condition alone will not suffice, the correction applied in the Royal Regiment of Artillery must also be applied. When a captain fails to attain the grade of major by regular promotion at 40 years of age he must be put upon a half pay list, a major at 48, and a lieutenant-colonel at 55. These officers go on the half pay list with the next grade, and then placed first on the rosters for recruiting, or other special duties which now take so many officers away from their regiments, greatly to the detriment of the service. While in the performance of the duties incident to such details, these officers to receive the full pay and allowances of their respective grades on the active list. This may be considered harsh as applied to individual officers, but without this provision in some form the service will inevitably be greatly injured in efficiency. Moreover the number of unfortunates will not be large if due care be taken in the beginning. The British military authorities found that individual officers blocked a proper flow of promotion, a situation that required their removal in some way, or the service must go on detriating with ever increasing force. As the misfortunes of the few individuals could not possibly be permitted to stand in the way of the good of the service, the above system was devised and applied, and under conditions which had grown so bad, that its application was harsh indeed, besides being extremely costly to the government. But since that first cruel cut it has been found to insure excellent results, and little or no complaints are now heard. It may also be stated that a part of the scheme was to make the commanders of horse batteries and perhaps other field batteries, majors in order to prevent an obnormally large number of captains from being placed on half pay. By giving the President the power to properly select the officers for the field artillery in the start, there need be no apprehensions for the future and as the officers so selected from the Artillery Corps go to another branch of the service, their new and increased rank will not stand in the way of their former fellows.

To the mind of the artilleryman it is quite evident why the artillery ammunition trains are so necessary, but in most armies such organizations are quite different from what is here indicated, being not only complete in every respect, but generally distinct from the artillery proper, yet intimately connected with it. In our service we can hardly expect the Congress to give us anything of this kind even in war, nor is it necessary that we should have the elaborate and extensive organizations that obtain in European armies even on a peace footing, though we should have constructed and kept in store the material complete, caissons, store-wagons, harness, etc., together with ammunition, necessary to hand in case of emergency. So that we may have in the event of war the necessary artillery ammunition trains adequate to immediately make good the waste of a battle, and hence very closely connected with the batteries, and under the immediate command and control of artillery officers.

While our army wagon is unquestionably very much better suited to hauling simply a load of ammunition than a caisson, and in a much more economical manner, it is quite evident that ammunition is not the only, and very often by no means the most necessary requirement after a battle.

PEACE ESTABLISHMENT.

	Officers	N.C.Staff	Enlisted	Batteries		Guns
				Gun	Train	
2 Regiments Horse Artillery	58	46	1054	12		48
2 Regiments Light Field Artillery	58	46	1054	12		48
2 Regiments Heavy Field Artillery	58	46	1054	12		48
1 Regiment Mountain Artillery	29	23	527	6		36
1 Regiment Siege Artillery	29	23	527	6		
Total	232	184	4216	48		180

WAR ESTABLISHMENT.

2 Regiments Horse Artillery	86	46	2846	12	4	72
2 Regiments Light Field Artillery	102	46	3546	16	4	96
2 Regiments Heavy Field Artillery	102	46	3546	16	4	96
1 Regiment Mountain Artillery	43	23	1421	6	2	36
1 Regiment Siege Artillery	75	30	2646	12	3	
Total	408	191	14,005	62	17	320

The dead and wounded men and horses must be replaced as well as the ammunition, and also the damaged or destroyed material. All of these things are vitally essential to the efficiency of the batteries, and it goes without saying that they cannot be supplied from trains made up from army wagons, but must be provided from specially organized artillery ammunition trains having all of the necessary ends in view. Empty or damaged caissons are replaced from the trains by loaded ones, empty ones can be hauled back to the depot by reduced teams, the extra teams going to make up the loss of those in the batteries, and drivers, cannoneers, etc., are taken to make good battle losses, all of these being made good to the trains when they return to the depot to renew supplies. Wagon trains were tried in every army for years, even generations after field artillery was first introduced, but have never been satisfactory anywhere or at any time, and hence their universal abandonment. If the artillery depot has to be established off a railroad or where water transportation is impracticable, undoubtedly the wagon will be by far the best to transport the ammunition and stores from steam transportation points to the depot, but it is entirely inadmissible for the immediate supply with an army in the field.

Although unforseen when organization was first worked out, it will be seen that, as we have thirty batteries, sufficient to organize five of the eight regiments to start with, the increase of one regiment each year will be twenty per cent., though of present strength not of the increase itself, it would also terminate in three, instead of five years as in the Artillery Corps. This will be another aid to the end of securing officers of ages suitable to their grades.

This force of field artillery is but the bare quota proportional to the present strength of the infantry and cavalry, and makes no provisions for any of the field artillery for a force of volunteers that will have to be called out in the event of war. In regularly organized armies for war, asuming unity as the strength of the infantry, the cavalry would be about $\frac{1}{6}$ and the artillery $\frac{1}{10}$. If we now had the above artillery organization these proportions would be, infantry 1, cavalry $\frac{2}{6}$, and artillery $\frac{1}{4}$. In other words the cavalry in our service measured by sabers, or by regiments, has double the normal proportion, while this force of artillery would be about 23 per cent. less in proportion than the cavalry. This would simply be following out for the field artillery the wise policy of the government, heretofore mentioned, of maintaining at the maximum strength those arms of the service in the regular army, requiring the most time and difficulty in training, entailing the greatest cost for maintenance, and finding little or no representation in the national guard or militia, and in fact cannot be expected therein because the cost to states would be entirely beyond any sum that even the most liberal state legislature would consider for a moment as possible.

So that as a matter of fact these branches of the service in our army ought not to be considered at all in connection with any proportions as to the infantry. This policy already applies with the cavalry. Field artillery is more expensive, requires more time, its instruction is much more complicated and difficult, and it should, if this policy is to be adhered to, find a proportional representation in our army even larger, rather than smaller than that of our cavalry.

Sir Charles Dilke in a recent article reviewing the modern military situation states: The mode in which a modern army on the anticipation of war prepares itself for the field is extraordinarily rapid in point of time as compared with the mode found necessary in the time of Napoleon Bonaparte; and it is this rapidity of mobilization and concentration which strikes the observer as the greatest change of the century in connection with armies.

The chief changes in the century have been a greater exactitude in these respects, a general increase of numbers (especially a great increase in the strength of field artillery), and in these last years grouping of the army corps into armies, which exist in Germany, France and Russia even in time of peace with all their generals and staffs named ready for war.

The cavalry and horse artillery kept upon the frontier are now in a condition of permanent readiness in the principal military countries as they would be used to cover mobilization of the remainder of the army.

The greatest change in the battlefields of the future as compared with those of a few years ago will be found in the development and increase of the artillery. A modern army when it takes up a position has miles of front almost entirely occupied with guns, and the guns have to fire over the infantry, because there is no room for such numbers of guns to be used in any other way. The attacking side (if both indeed, in one form or another, do not attempt attack) will be chiefly occupied in obtaining positions on which to place its guns, and the repeating rifle itself, deadly as is its fire, cannot contend at ranges over 1000 yards, unless the riflemen are heavily entrenched, with the improved shrapnel fire of modern guns. The early engagements of a war will indeed be engagements of cavalry massed upon the frontier on the second day of mobilization, so rapid will the opening of war in the future be. This cavalry will be accompanied by horse artillery and followed by light infantry, constantly practised in rapid marching in time of peace, or by mounted infantry. But the great battlefields of latter weeks will be battlefields above all of artillery.

Fort Screven, Ga., A. D. Schenck,
March 7, 1901. Captain, Artillery Corps.

SIGHTS FOR DIRECT FIRE GUNS.

Certain objections to the method of graduation of the sights for direct fire guns in our service are so obvious that to name them can be but to enumerate ideas that have passed through the minds of almost all artillery artillery officers. Range on these sights is marked in its equivalent of degrees and minutes, while our range finders give us distance in yards. It is therefore necessary to resort to tables to convert the yards given by the range finder into degrees and minutes required at the gun. This conversion is required to be made by the battery commander at the range finder, the results being sent to the gun by telephone or by some better method not yet brought to light. The efficiency of the guns thus depends upon the ability of the working force in the range tower to make nice mathematical calculations exposed to the enemy's fire. If communication with the gun be interrupted, or if the range finder be dismounted, broken, or even very much disturbed, or if the working force be distracted, maimed, or killed, the men at the guns will be thrown upon their own resources. To hope that any one of these calamities will not befall us in our first real trial, is to expect the attack of a foe too feeble for serious consideration.

Hence it is necessary that gun commanders be provided with range tables, that they are able to use them accurately and quickly, amidst great confusion, and at a time when they will be called upon to perform a multitude of other duties. If we should admit, what with more reason may be denied, that, after supplying the range finder with expert gunners, a battery commander could supply one man to each gun capable of doing this exacting work, yet the efficiency of that gun will in the last resort depend on the life of this one gunner. His death, the loss of his flimsy range tables, or his neglect or inability to supply himself with them at the beginning of the battle, will put his gun as effectually out of action as would the best aimed shot of the enemy.

Were elevations on the sights marked in yards the question would bear a different aspect. No conversion of yards into degrees and minutes would have to be made in the range tower, and the working force required there would not have to be so large. A greater number of expert gunners would therefore be available for the service of the guns. Time would be saved, and errors inevitably incident to the hurried use of range tables would be avoided. In peace practice it is not found practicable to transmit degrees and minutes by telephone without frequent errors; because the telephone operators so often confuse the number of degrees with the number of minutes. No such difficulty is found in sending distances in yards.

For these reasons it must be evident to all that the range finder could furnish good information to the gun much longer where so much less is exacted from the working force. But even if the range finder be put out of action the efficiency of the guns would not, if the sights were graduated in yards, depend upon the possession by some member of the crew of a perishable range table and the ability of a surveyor to use it. Most men can estimate distances in the common linear units with some degree of accuracy, and the rawest recruit could set off these distances on sights graduated in yards; but no mortal being could estimate distances in their equivalents of degrees and minutes. Few men can even set sights marked in degrees and minutes with rapidity and precision.

Since therefore sights graduated in yards have such great advantages over sights graduated in degrees and minutes, it is necessary to inquire why, with few exceptions, all of our sights have the more complex graduation. No standard service powder has so far been adopted for the use of the coast artillery. Different kinds of powder are used for the same gun; charges of the same powder vary in size; and not infrequently projectiles of different weights are used. Moreover the ballistic value of the charcoal powders varies on account of their age and moisture. In sights using quadrant elevations, the elevation required to fire at any given range is modified by the height of the gun above the sea. Because of these ever changing elements it has been found easier to furnish range tables than sights to suit the different kinds of powder. Moreover, the artillery is called the "scientific branch of the service" and a feeling prevails that nothing can be too abstruse for the enlisted men of that arm. Indeed a premium is set upon ability to confound and darken simple things. The 4.72″ B. L. rifle purchased abroad in 1898 was issued to the service with sights graduated in yards, and the best results were obtained in using them. These sights are being re-graduated in degrees and minutes.

It has been suggested that sights for direct fire guns be furnished with a number of detachable face plates graduated for different velocities and for the particular gun.* From a trial shot using quadrant elevation the velocity given by any powder is easily determined,* and little time and skill would be required to fit the proper plate. The cost of furnishing every gun with plates having graduations for variations of 10 f. s. muzzle velocity for all velocities likely to be required would be trifling. With a series of plates having a difference of 10 f. s. muzzle velocity, the greatest error in selecting the proper plate would be 5 f. s. muzzle velocity. The vertical error resulting from an error of 5 f. s. with the 10-inch B. L. R. steel, at 5000 yards, a range at which no naval vessel would fire on land works, is six feet. If the difference of graduation were 20 f. s. the vertical error for the same gun at the same range would be about 12 feet.

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* For this suggestion I am indebted to Captain E. W. Hubbard, Artillery Corps.

It would appear, therefore, that a difference of 20 f. s. in velocities for the face plates of sights would not be too great. With this difference a plate could be selected within 10 f. s. of any velocity. There is perhaps no lot of powder in any magazine in the United States that has been in store for any length of time that would give a velocity within 10 f. s. of any printed range table in existence. To expect that any one in actual battle will apply the corrections for difference of velocity as contemplated in our range tables, is to expect what will never be done. With smokeless powder there will be little deterioration; muzzle velocities will not vary so much; and few plates would be required.

If the proposition for the use of graduated plates to be placed upon the front of sights be thought fanciful and impracticable, the fact remains that the cost of supplying a gun with vertical limbs for its sights graduated in yards for muzzle velocities with differences of 20 f. s., or even 10 f. s., for all velocities likely to be required, would be small, and the resulting advantages inestimable.

By either method the time required to use range tables would be saved; errors of conversion would be eliminated; the possibility of losing tables in action would be averted; the danger of losing important members of the gun crews would be lessened, because fewer men being required at the range tower, a greater number of instructed men would be available for the service of the gun, and the duties of a gunner being less exacting, a greater number of men could be qualified and all would be more proficient; the difficulty of remembering and transmitting absurd units would be avoided; in case of errors by gunners in setting sights, they would be more readily detected by members of the crew, if the sights be graduated in units commonly known to them before entering into the service; the system would be adapted for the use of volunteer troops and newly recruited regulars; and ease and celerity in applying corrections from observation of previous shots would be gained.

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* The I. V. may be obtained by using the well-known formulæ of ballistics. I think it could also be very readily and accurately obtained by constructing graphic range tables similar to those used with the 12″ B. L. mortar, by taking elevations from about 2 degrees to about 6 degrees and velocities from 1875 f. s. to 1975 f. s. as co-ordinates (for the 10″ B. L. rifle) and drawing in curves of ranges. These should be made upon heavy paper, and, as they would perhaps never be used in action, they could be made to a large scale. Before target practice or upon the breaking out of war, post commanders should fire to test for velocity. All of the refinements of ballistics may here be attended to and the results imbodied in the sights.

Some may say that the cost of firing a modern gun is so great that no means should be spared to increase accuracy of fire; that the least count of a scale of degrees and minutes may be made smaller than the least count of a scale of yards, since it is not possible to apply the usual form of vernier to the latter; and that men will work diligently to obtain and apply small corrections in minutes which, if they were expressed in yards alone and the real value were thus made glaringly apparent, would be passed over as unimportant. These arguments would be unanswerable if time were not of vital importance in all warfare. While we shall have been working out corrections for changes of velocity and atmospheric conditions, the enemy will have passed over many times the corrected differences and our shot will miss the target; and moments during which other shots might have been fired and hits made, will have been thrown away. The evils that will come upon us if we continue this overheated race after accuracy should no longer pass undiscerned or unheeded by those whose time is spent in the endless task of teaching that which when mastered is well-nigh useless.

The impropriety of giving the artillery gunner a sight requiring the use of a paper table is as great as it would be to give the infantryman a rifle requiring a similar table. The absurdity is less apparent because it has not been found practicable to hedge the infantryman about with so much pedantry. The studious man who wishes to go through all the operations of ballistics every time a shot is fired should be made to content himself with a table printed on thick paper giving the time of flight of the projectile, its striking velocity, and its penetration in steel. In case of sudden attack upon any fortress, how many of its guns would be provided with range tables and range scales? If once fully provided, how long would they stand the effects of rain, wind, and greasy fingers?

Corrections in azimuth must be made for the speed of vessel,

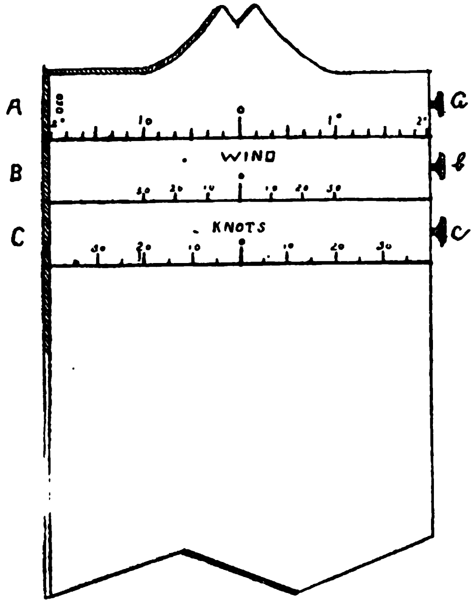

Fig. No. 1.*

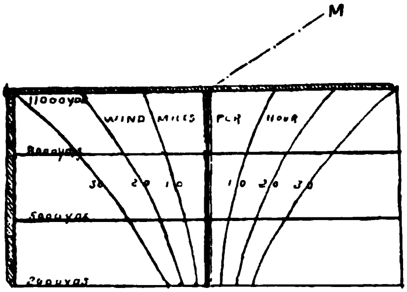

Fig. No. 2

for the effects of the wind, and for drift. In addition, means should be provided to apply corrections from observation of last shot. Correction for drift should be provided for in the construction of the sight. I would suggest that the other corrections be made by means of three sliding scales. In figure 1, C rests upon the limb of the sight and is graduated in knots for speed of vessel for the mean range of the gun. It is worked by the screw c. The azimuth correction for speed of vessel may be made by holding the sights on the vessel during the flight of the shot, noting the change of azimuth in degrees and minutes; but, as it may not often be found practicable to make this observation, and as the idea of making corrections for the estimated speed of vessels is very prevalent in the artillery, provision should be made for applying this correction in the units in which the estimations are made. B is graduated for the effect of the wind across the range in miles per hour, the units given by the anemometer for mean range. It rests upon C and is worked by screw b. A is graduated in degrees and minutes for correcting the azimuth from observation of the fall of the previous shot. By this arrangement no calculation is required for corrections in azimuth. In actual battle no account will be taken of the effect of the wind and speed of vessel across the range unless corrections be made almost automatic.

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* Each scale in the figure should have a pointer below it.

If corrections for mean range for the effect of the wind be not considered sufficiently accurate, I would suggest that slide B be graduated as shown in figure 2. Let the horizontal lines represent ranges, the curved lines the resulting corrections for the effects of the wind drawn to scale. The pointer M may be set at any range for any given velocity of the wind. Interpolation for differences of range and wind would be easy. I am inclined to think that correction for mean range is to be preferred for the sake of simplicity.*

The maneuvers of Narragansett Bay in the year 1900, demonstrated that a gun cannot be sighted if a powerful search light be turned upon the gun so as to blind the gunner. While it is admitted that a search light near the gun, in some degree, obviates this difficulty, no gun should be dependent upon the protection of a friendly search light. By placing a plane lens of dark glass in front of the front sight, and by using night sights similar to those furnished with the Armstrong R. F. guns now in service, I am inclined to think that the gun could be trained upon the enemy's search light itself, and by aiming slightly below the search light, upon his vessel. Two or more lenses of different degrees of opacity should be provided, and they should be pivoted so as to be turned aside when not in use.

S. C. VESTAL,
1st Lieutenant, Artillery Corps.

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* A curve may be drawn for drift similar to the curves for windage, the tangent of curvature being greater. It would lie to the right of the zero for tangent sights, and to the left for Scott sights. When compensation for drift is not made in the construction of the sight, slide A of figure 1 may advantageously receive a double graduation, the upper edge being graduated for drift for each 1000 yards. Two graduations upon one slide should generally be avoided because they almost necessarily introduce calculation and the use of thumb rules; moreover the setting of the sight could not be so readily verified by a superior. The oldest gunners forget their rules at target practice and at examinations. What may we expect in battle? Upon reflection, however, it will be evident that there can be no objection to putting a double graduation upon slide A; since the graduation in terms of drift for each 1000 yards will be required for the first shot only, while the graduation in degrees and minutes will not be required until after the first shot has been observed.

The foregoing remarks are made with reference to the tangent sights, but, with modifications, they can be applied to the Scott sight. For instance, the sliding leaf of this sight might receive the double graduation suggested in this note, and the sight itself might be provided with detachable limbs for difference of I. V.

THE SPANISH DEFENSES OF SAN JUAN, PORTO RICO.

At the time of the transfer of the sovereignty of Porto Rico to the United States (October 18th, 1898), the fortifications at San Juan were occupied by Batteries "B" and "G," 5th Artillery, and since that time they have been regularly garrisoned by various batteries of that regiment.

No alterations have been made and the defenses are practically in the same condition as when received.

An inspection of the map shows the principal features of the system of defense which was, briefly: to oppose the entrance of the channel and bay by the group of works around El Morro; to reply to bombardment from the sea and prevent anchorage by the fire of all the batteries; and to defend the island from attack from the main land in the vicinity of the San Antonio bridge by the land fronts of San Cristobal and the new works at San Ramon.

The history of the Island tells of numerous attacks by one or all of these methods, none of which were entirely successful; but until the growth of the City made necessary the destruction of portions of the encircling wall, that must have been regarded as the final line of defense. In 1895, the eastern section was leveled and the old gateway destroyed.

The modern coast defenses date from about 1887; some guns were mounted as late as February 1898. Undoubtedly there were many older sea coast guns, muzzle loaders; some are lying around and a few are still mounted. But the armament in 1898 was composed of twenty-five 15 cm. rifles and ten 24 cm. howitzers, all breech loaders, made in Trubia, Spain, between 1889 and 1894 and mounted on barbette hydraulic buffer carriages of about the same dates. A few rapid-fire guns of small calibre, some siege guns and siege mortars were also in the works; the number and location of these is unknown.

Beginning west of the entrance we find works just begun on Cabras Island, and a very small stone fort known as Canuelo; no guns of position were mounted at either; some light guns were probably at Cabras Island, which was designed to be a strong water battery defending the channel.

Next, at the western end of the Island of San Juan, we have the group around El Morro, consisting of sixteen 15 cm. rifles and two 24 cm. howitzers in several detached works along the old wall and on the fort itself, the heights varying from 70′ to 170′ above the sea. These guns cover at short range the entrance channel which is narrow and crooked at best, and many of them can be used against a fleet at sea. There are also six 21 cm. muzzle loading howitzer with studded projectiles mounted near by, bearing on the channel only.

The parapets here are mostly the old walls backed up by varying thicknesses of earth and work, with concrete interior walls; and the older works converted into magazines and storerooms.

The old Fort El Morro is a closed masonry work with bastions on the land front: it commands the city as well as the bay, and rises about 150 feet above the sea with several tiers of works for old cannon, some in casemate and some in barbette.

From El Morro to San Cristobal is about a mile and though the bluff and wall rise at places to 120 feet, no modern guns are mounted here.

The group at San Cristobal consists of six 15 cm rifles and five 24 cm howitzers, all having a wide sweep to sea. There are also three 15 cm rifles facing the bay and sweeping it and the shores beyond thoroughly.

The heights of this group vary from 57 to 149 feet: they are well protected by earth and concrete and were built about 1896. La Princesa battery is especially well built, and the magazines, shelters and storerooms are complete in every respect: the parapet is about 40 feet of natural rock and earth with a concrete interior wall averaging three feet in thickness. The two rifles and two howitzers were mounted in 1897 and 1898.

The older works of this group consist of the Castle of San Cristobal and its outworks—a modified Vauban front with the bastions, redan, lunette and redoubts of that system, connecting at both ends with the city wall, now partly destroyed. These works are pierced with many embrasures and command the city, the sea, the bay and beyond the San Antonio bridge.

At the northeast corner of the Island is the final group—a modern battery of three 24 cm howitzers, called Escambron, 46 feet above the sea, excellently situated with natural rock parapets and well protected magazines.

South of this are unfinished emplacements for rapid fire and siege guns commanding the bridges and the little towh Santurce on the main land.

A small fort or castle (San Geronimo) now entirely dismantled was formerly the defense of this entrance which until the bridges were built was frequently used by small boats.

At El Morro is a covered station with plotting room which the Spaniards used as the principal station of a horizontal base of about 3000 yards. Whatever instruments they had were taken away: it is understood that a telephone line connecting the stations and several batteries was in use.

There are three large storage magazines on San Juan Island: they are well protected either by natural features or by heavy parapets.

The 15 cm rifle (Trubia) is a built up gun, apparently consisting of a tube and jacket only. Star-guaging shows that the tube does not extend to the muzzle. The metal is steel of good quality, but the gun seems very light for the work intended. The 24 cm howitzer has a cast iron tube with two or three steel hoops. The twist in both is increasing all the way to the muzzle; and the powder chambers are slightly elliptical.

Both guns have the French breech-block with a modified Broadwell ring which is of copper. The breech-block is rotated by a lever which in the 15 cm rifle is locked for firing and started by unlocking; in the 24 cm howitzer the main lever is started by an auxiliary lever; being rotated, the block is drawn by hand to a hinged tray with the usual locking devices.

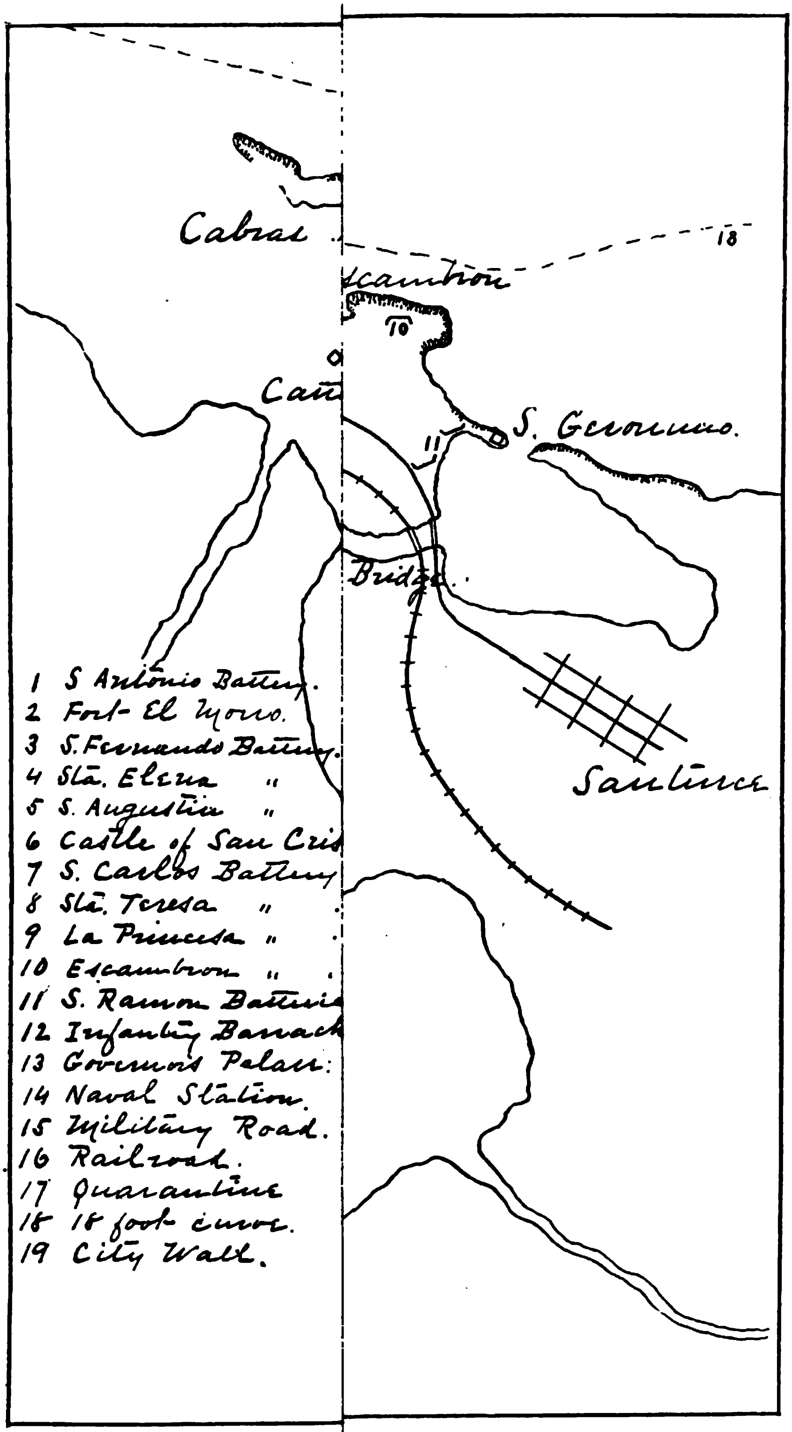
The sights are plain tangent sights graduated to millimeters; with a deflection scale also in millimeters; the howitzers have carriage signts also, and graduated trunnion arcs. The elevating devices are arcs with gearing, hand wheels and clamps: the traversing is done by gear wheels working into teeth on the bedplate of the howitzer and into the rear wheels of the rifle carriage.

Azimuth graduations and pointers are on some carriages: the bearings of fixed points are marked on the concrete of a few of the emplacements.

The 15 cm carriage is much like our 8-inch converted rifle carriage: it has two hydraulic cylinders without any equalizing pipe. The 24 cm carriage is very heavy; the chassis rails have considerable inclination to the front with two hydraulic cylinders, without equalizer, set parallel to the rails, and the whole mounted on live conical rollers and very small chassis wheels.

The cylinders of the 15 cm rifle carriage have but one throttling bar: those of the 24 cm have three.

There are different types of projectiles: armor piercing shot; cast iron shot; forged shell; common shell and shrapnel: a great number of both varieties. Some of the projectiles were left filled and fuzed; the bursting charges have, in most cases, deteriorated badly.


Cabras
scambron
10
Cañ
S. Geronimo.
11
Bridge.
18
Santurce
1 S Antonio Battery.
2 Fort El Morro.
3 S. Fernando Battery.
4 Sta. Elena "
5 S. Augustin "
6 Castle of San Cris
7 S. Carlos Battery
8 Sta. Teresa "
9 La Princesa "
10 Escambron "
11 S. Ramon Batteri
12 Infantry Barrack
13 Governors Palace.
14 Naval Station.
15 Military Road.
16 Railroad.
17 Quarantine
18 18 foot curve.
19 City Wall.

The fuses are of two classes, percussion and time-concussion: the former are simple and efficient: the latter are excellent in principle but have become mostly worthless due to deterioration of the time train.

Most of the powder left is one canal, black hexagonal made in Murcia, Spain, from 1893 to 1897: it is very well packed and has given uniform results. There is some older seven canal powder which is unreliable.

The equipments are generally complete: the magazines perfectly dry and the positions well-chosen, well protected and well drained. Covered ways extend to most of the batteries.

All of the guns were used against Sampson's fleet during the bombardment of the city on May 18, 1898, without material damage to the fleet: nor did the fire of the ships do any permanent injury to the fortifications. El Morro bore the brunt of the attack and the old walls were struck a great many times, but the batteries apparently escaped, as in October, 1898, there was not a sign of damage to the modern guns. The Naval accounts report the only injuries to the fleet to have been from the eastern batteries, probobly "Sta. Teresa" and "La Princesa" of the San Cristobal group. The Spanish gunner of the gun now known as "No. 9, Sta. Teresa," is said to have been rewarded for the shot which damaged the New York and killed the only man on any of the ships.

The fire commander's station is now at San Cristobal: emergency position finders are established at the batteries, and telephone lines connect the old Spanish base line with these new stations and all the guns.

The 15 cm rifles have recently been fired with charges of 33 pounds one canal, black prismatic powder (Murcia, 1897) with weight of shot averaging 109 pounds, giving a mean initial velocity of 1649 feet with pressures around 26,000 pounds. 36¼ pounds of the same powder was also used giving an I. V. of 1721 feet (mean) with pressures around 31,000 pounds. With Murcia, 1893 powder, the velocities and pressures were slightly less. Different elevations were used up to 19° 20′ (quadrant) giving ranges to 9100 yards.

The 24 cm howitzers were first fired with 22 pounds of the same powder (1897) which was said to be the full charge. The weight of shell averaged 300 pounds: the mean initial velocity was 748 feet and the pressure less than 6000 pounds. The charges were increased to 33 pounds, then to 40 pounds, and finally to 44 pounds (I. V. 1145 feet, P. 20,300 pounds) which started the last hoop on the breech of the howitzer: the charge was then reduced to 40 pounds and the firing continued with the same gun. Elevations from 5° to 60° were used without the slightest injury to the carriages; the most severe test being with 44 pounds at 45° which gave a range of 9714 yards computed from the base line and checked very closely by the position finder.

The firing in which different rifles and howitzers were used was very satisfactory both at El Morro and San Cristobal, and showed that the guns, carriages and powder were better than supposed: in all about seventy shot and shell were fired without the slightest incident or accident due to this firing.

While the guns are far from being the ballistic equals of those on modern men-of-war, the advantages of height and position are such that with a proper complement of rapid fire guns, the batteries ought to put up a good defense against any fleet, though they could not prevent the bombardment of the City at long range. They should be increased by several groups of high-power guns for which there are some fine positions.

San Juan, P. R., A. C. Blunt,
March 20, 1901. Captain, Artillery Corps.

THE DEVELOPMENT OF THE KRUPP FIELD ARTILLERY MATERIAL.*

(Translated from the German by M. WILLIAMS, and arranged for publication in the office of the Chief of Ordnance.)

(Concluded.)

V.

SHRAPNEL.

The main use of shrapnel as a scattering projectile, exploding in the air, is its great dispersion in range against live, uncovered, or slightly covered objects. All efforts of construction which tend to promote this main object of shrapnel must be considered successful, whereas all others are useless.

INTERIOR ARRANGEMENT.

Of the three constructions, head chamber, body chamber, and base chamber, the latter is, according to the above-mentioned point of view, the most suitable, because it keeps the shot closer together—that is, it gives a more slender cone of splinters, which prevents too rapid opening of the sheaf of dispersion.

The superiority of the base-chamber arrangement consists, furthermore, in that it gives the fragments an increased velocity, thus increasing the effective range of the individual balls. To obtain the measurement of this increase, tests have been carried out in three different ways.

It is noticeable that the increased velocity is only slightly less when the case bursts than when it remains whole. This difference is so small that it is often impossible to determine it, either when measuring the increased velocity or the angle of dispersion.

If the case is reduced to numerous small fragments, the increased velocity may be 10 per cent less than when the case remains whole. The increase of the angle of dispersion in this instance amounts at the most to 3 degrees. As against these altered measurements, the shot receives an increase of five to ten fragments.

It must be noted that it is not difficult for the manufacturer to make the cases so that they will not burst. This is attained by changing the material used, strengthening the walls, and reducing the powder charge in the base chamber and the transmitting charge in the chamber tube. The result of strengthening the walls is that the case contains fewer shot. The decrease of the explosive charge lessens the increased velocity of the balls, so that the increase becomes less rather than greater in comparison to those constructions which carry a somewhat greater explosive charge, but bursting walls.

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Furthermore, the form of the head of the shrapnel is of influence, as the base of the fuze is usually smaller than the diameter of the projectile; consequently either the case must be narrowed down in front or else there must be introduced between it and the fuze an easily detachable or an easily breakable intermediary. If the case is not to tear open, and it is not desirable to strengthen the walls in connection with an especially tough material, only the construction with an intermediate piece may be used. Weight and space thereof reduce the number of shot and the effective utilization of shrapnel; hence a projectile drawn in forward, with a case generally tearing open upon explosion, is superior to the other sort.

The comparison of the two base-chamber shrapnel constructions shows, with a non-bursting case, a smaller number of balls and fragments and a somewhat smaller cone angle; with bursting case, a greater number of balls, a greater fragmentation, a somewhat greater angle of sheaf, and with both about the same increase of velocity. The Krupp factory considers it the best solution of the question to unite the advantages of both kinds of shrapnel—that is, to attain, on one hand, the greatest number of balls and the greater utilization; on the other hand, by the choice of the most suitable material, to so control the bursting of the cases that they shall not be shattered into too many very small fragments, because in this case the conditions mentioned would become less favorable. To obtain this the case bursts or not, as may happen.

As against an increase of velocity in the case of the base-chamber shrapnel, there is a decrease of velocity in the head-chamber shrapnel. The advantages attributed to the head-chamber shrapnel, that the balls in the cone of dispersion are more uniformly distributed, an that, owing to the absence of the base chamber, their number can be correspondingly increased, are so insignificant that they do not count as against the above-mentioned drawbacks. The third variety, middle-chamber shrapnel, is unsuitable, because the cone angle is too great and because the balls scatter only on the cone surface. The greater the explosive charge used with this shrapnel, as is sometimes done to unite the effectiveness of a shrapnel with that of a shell, the more faulty is the construction, because it counteracts the main object of shrapnel, viz, great effective range. Formerly the base-chamber shrapnel was occasionally objected to, on the ground that the cone angle was too small, and that at short distances beyond the bursting point there was a superfluity of force expended in a small space, and at great distances beyond the bursting point effectiveness perpendicular to the enemy's line did not occur, because the angle of fall would then be greater than half the cone angle. Moreover, the upper half of the cone of dispersion of the balls, chiefly important for effectiveness in the direction of the plane of fire, had only a short flight, whereas with the middle-chamber construction, therefore with a greater cone angle, the upper part of the cone of dispersion, nevertheless, has usually the desired efficiency in that direction.

In older guns, with smaller twist of rifling, comparatively less muzzle velocity and short projectile, therefore a projectile of less sectional density, this criticism of the base-chamber shrapnel was justified to a certain degree, but in the case of new, ballistically perfected guns it is not. Furthermore, in new constructions now in hand, by the use of a higher initial velocity, thereby increasing the speed of rotation, the cone angle can be increased.

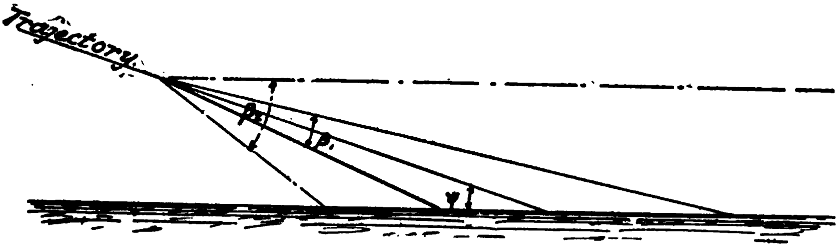

Fig. 24.

In fig. 24, ψ shows the angle of fall of the still unexploded shrapnel. Let β_1 be a cone angle which is smaller than the double angle of fall, then $\frac{\beta_1}{2} < \psi$. Let β_2 be a cone angle which is equal to the double angle of fall, then $\frac{\beta_2}{2} = \psi$.

The superiority of the last condition for a favorable range efficiency of the upper portion of the cone of dispersion is apparent from the sketch.

The material for balls used by Krupp's factory is hard lead, an alloy of lead and antimony, having a specific gravity of 10.4. The use of loading pieces besides balls—that is, laying the balls in cast-iron plates with corresponding indentations to increase in this way the effective weight of the shrapnel—is not recommended, because the pieces, owing to their lower density and irregular shape, encounter great atmospheric resistance and therefore only have sufficient energy for effectiveness near the bursting point—that is, for short bursting height. It gives a false idea of the value of shrapnel if the weight of the loading pieces is counted and the result is compared with utilization figures of shrapnel without loading pieces.

To hold the balls in place resin has proved to be best. Part of the space between the balls can be filled up by some smoke-producing material to increase the volume of smoke. The factory has made numerous experiments in this direction. Only such smoke producers have been successful as have for basis either strong poisons, such as phosphorus or arsenic, of the durability and the influence on surrounding materials of which no satisfactory experience is adducible, or else easily oxidizable metals. The best smoke developer is the explosive charge itself. It is not desirable to carry the development of smoke too far, for since the universal adoption of smokeless powder even small clouds of smoke are sufficient for observation, and a too heavy smoke from one's own projectiles can be, under some circumstances, very troublesome because of its interference with observation.

TABLE VI.—CALCULATED VALUES OF THE EFFECTIVE RANGE OF SHRAPNEL BALLS.

I	II	III	IV	V	VI	VII	VIIa	VIII	IX	X	XI
No.	Weight of each ball.	Number of balls per pound.	Diameter of balls for a specific gravity of 10.4 to 10.5.	Sectional area.	Sectional density in pounds per square inch.	Velocity of impact corresponding to an energy of impact of—		Effective range of balls for initial velocities of the projectile of 1,312 1,148, and 984 feet per second, corresponding approximately to velocities of the shrapnel at point of burst of 1,148, 984, and 820 feet per second.			Remarks.
						58 foot-pounds	116 foot-pounds	I. V. projectile: 1,312. Remain.vel. shrapnel: 1.148.	I. V. projectile: 1,148. Remain.vel. shrapnel: 984.	I. V projectile: 984. Remain.vel. shrapnel: 820.	
	lbs.		*inches*	*sq. in.*		*ft. sec.*	*ft. sec.*	*yards*	*yards*	*yards*	
1	0.0265	37.74	0.5118	0.2059	0.1287	374	—	425	405	371	The effective range of balls is the distance from the point of dispersion (burst) to the point where the remaining energy of each ball is 58 and 116 ft.-pounds, respectively.
2	0.0265	37.74	0.5118	0.2059	0.1287	—	532	252	232	198	
3	0.0243	41.15	0.4961	0.1932	0.1258	394	—	386	366	336	
4	0.0243	41.15	0.4961	0.1932	0 1258	—	554	230	211	177	
5	0.0220	45.45	0.4803	0.1810	0.1215	410		357	337	304	
6	0.0220	45.45	0.4803	0.1810	0.1215	—	581	208	189	156	
7	0.0198	50.51	0.4646	0.1695	0.1168	433	—	317	299	267	
8	0.0198	50.51	0.4646	0.1695	0.1168	—	614	183	164	132	

WEIGHT OF BALLS.

Calculated values for the limit of efficiency in the direction of range of the various weights of balls and final velocities are given in Table VI, from which it appears that with due regard to the final velocity of field shrapnel corresponding to great fighting distances, it is not desirable to reduce the weight of the individual ball below 10 grammes; that, on the contrary, it is desirable to maintain the weight of 11 grammes. As the table gives the efficiency in the direction of range for velocity of flight for every 50 m. s. and as this last measurement is about equal to the increase of velocity due to the base-chamber explosive charge, it can be seen from the table how much the efficiency in the direction of the range is increased by this additional velocity. To verify the table, targets made by single shrapnel rounds can serve. These were produced with heavy explosive charges against plank walls, as also by the test firing of a musket loaded with shrapnel balls.

TABLE VII.—BASE-CHAMBER STEEL SHRAPNEL, MANUFACTURED FOR RAPID-FIRE FIELD GUNS.

No.	I	II	III	IV	V		VI		VII				VII	IX
					Weight of bursting charge.*		Fuze.		Balls.					
										Weight.				
	Caliber.	Weight of projectile.	Sectional density in pounds per sq. inch.	Approximate length.	Pounds.	Percentage of wt. of projectile	Time of burning	Weight.	Number.	Of each ball.	Total.	Percentage of weight of projectile.	Greatest initial velocity.	Remarks.
	in.	*lbs.*		*calibers.*			*sec.*	*lbs.*		*lbs.*	*lbs.*		*ft. sec.*	
1	2.36	6.61	1.511	3.4	0.088	1.33	11	0.84	100	0.0227	2.27	34.3	1,640	The shrapnel are arranged chronologically as to origin; those that were originated at about the same time are tabulated according to caliber and weight.
2	2.36	7.72	1.765	3.9	0.093	1.20	11	0.84	135	0.0227	3.06	39.6	1,640	
3	2.56	9.92	1.927	4.0	0.099	1.00	16	0.88	170	0.0209	3.55	35.8	1,837	
4	2.76	8.82	1.474	2.9	0.119	1.35	17	1.10	130	0.0243	3.16	35.8	1,476	
5	2.76	11.02	1.842	3.5	0.143	1.30	17	1.10	180	0.0243	4.37	39.7	1,640	
6	2.95	9.48	1.387	2.6	0.143	1.51	17	1.10	142	0.0243	3.45	36.4	1,476	
7	2.95	11.68	1.709	3.1	0.139	1.19	17	1.10	190	0.0243	4.62	39.6	1,640	
8	2.95	13.23	1.936	3.6	0.209	1.58	17	0.10	210	0.0243	5.10	38.5	1,640	
9	3.15	15.43	1.980	3.3	0.154	1.00	16	0.88	240	0.0247	5.93	38.4	1,837	
10	3.15	16.53	2.121	3.6	0.165	1.00	16	0.88	260	0.0247	6.42	38.8	1,837	
11	3.23	15.43	1.883	3.0	0.187	1.21	16	1.88	180	0.0331	5.96	38.6	1,640	
12	2.95	14.33	2.097	3.85	0.198	1.38	17	1.10	250	0.0243	6.08	42.4	1,640	
13	2.95	13.23	1.936	3.55	0.165	1.25	20†	0.71	256	0.0243	6.22	47.0	1,969	
14	2.95	14.00	2.048	3.7	0.165	1.18	20†	0.71	274	0.0243	6.66	47.6	1,969	
15	2.95	14.33	2.097	3.75	0.165	1.15	20†	0.71	277	0.0243	6.73	47.0	1,969	
16	3.00	14.00	1.981	3.65	0.165	1.18	20†	0.71	274	0.0243	6.66	47.5	1,969	
17	3.07	14.33	1.936	3.5	0.165	1.15	20†	0.71	277	0.0243	6.73	47.0	1,969	

* Inclusive of central tube for filling chamber.

† The principal parts of these 20-second fuzes are made of aluminum alloy.

WEIGHT ECONOMY OF SHRAPNEL.

Table VII gives a report of the shrapnel made by the Krupp factory, from which can be seen the weight economy thereof—that is, the effective weight of the balls. It shows that this utilization in general is greater with increased caliber and increased weight of projectile, that the improvement of the utilization progresses much more slowly than the caliber and weight of projectile, and very little improvement is evident between the principally interesting limits of 7 cm. (2.755 inches) and 8 cm. (3.149 inches) caliber on the one hand and 3.1 and 3.9 diameters of length of projectile on the other.

The latest Krupp shrapnel shows weight economy, which until recently was considered unattainable with base-chamber constructions. This perfecting was made possible by:

1. Improvement of the steel of the case, resulting in thinner walls.

2. Lightening of the fuze by the use of aluminum alloy instead of brass.

3. Abandoning the consideration of other kinds of projectiles in the effort to obtain equal length, equal weight, and equal trajectory conditions.

USE OF SHRAPNEL WITH PERCUSSION FUZE.

If only the greatest effectiveness of shrapnel, as a scattering projectile exploding in the air, is being worked out, the question is, Can a good result be obtained for purposes formerly accomplished by shell? Here we must consider:

1. Firing at animate objects with shrapnel, the fuze of which is set for percussion. Such methods of firing, especially at moving objects at close range, may be advisable on account of greater simplicity and the possibility of increased rapidity of fire.

2. Firing at resisting objects such as occur in field warfare, for instance, garden walls, light buildings, etc., for which the striking power of the whole projectile, and if possible, the subsequent splintering effectiveness is required. Tests were made for this object, with 7.5-cm. (2.95-inch) steel shrapnel.

From the records it was seen that shrapnel was equal to the requirements set forth under both 1 and 2.

EXPLOSIVE CHARGE.

For an explosive charge, ordinary fine-grained black powder is used, and for transmitting charge in the chamber tube, hollow pressed powder cylinders serve. For weight of explosive charge, see Table VII.

FUZES.

Krupp's factory uses the combination fuze represented in figs. 25*a*, 25*b*, and 25*c*, which adapts itself to the shape of the projectile and time train, which has lately been increased to 20 seconds.

Variations in the time of burning have been tested under various conditions with Krupp fuzes. Among them are those tests made from different heights of position, and with guns of small caliber, with varying velocities of flight and angular velocity of the projectiles. To judge of the relation between the fuze variation and the variation of the time of flight of the projectile, which together make the variations in the time of burning, tests of accuracy of fire were made with the same projectiles, with percussion fuzes; also, tests of variations in the time of burning were determined from the burning of fuzes in projectiles not fired from guns.

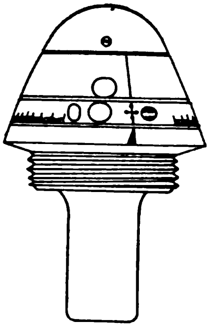

Fig. 25a.

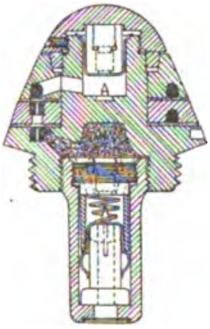

Fig. 25b.

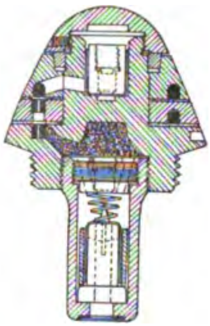

Fig. 25c.

The division of the fuze time-adjusting piece, by Krupp's factory, is generally made in seconds and tenths of seconds. If the fuze is to be used for different projectiles, guns, and muzzle velocities, this alone would prevent the division according to range. In some countries such great varieties of elevation and climate of the seat of war prevail that, even with the same gun, important differences of the time of burning for a determined range occur. Finally, the division of the fuze for range has the further drawback that in order to reach an agreement between the division on the fuze and that on the aiming sight, a special device must be provided either on the latter, or on the fuze, to change the zero point. If it is desired to graduate the time of burning for range, and to use the fuze for different guns, it is best to keep the division of seconds on the fuze itself; for setting, automatic regulating keys should be used, with a movable zero-point and range space, the division of which corresponds to the ballistic conditions of every sort of gun. Such regulating keys must not only be very exactly made, but also require that the fuzes should be constructed with a minimum of variation, if otherwise the variations in time of burning are not to be considerably increased. The mean variations in time of burning will increase with the use of a regulator, but extreme variations will be less frequent, and the entire variations, counting the latter, will be smaller. Krupp's factory has constructed various kinds of automatic regulators, but they have not been extensively used. A comparative table of variations in time of burning, tested under rapid fire, with and without a regulator, has been constructed.

In any case, time fuzes for use in rapid fire must be easily set, without necessitating tightening of the screw; however, they must not turn so easily that their position changes during firing. The Krupp devices are constructed according to these requirements. (Imperial German Patent 69.743, of October 22, 1892.)

WEIGHT OF PROJECTILE AND MUZZLE VELOCITY.

If in a certain construction the muzzle energy has been determined, or, if on the strength of the latter, the lines of a certain gun have been laid down, it must still be considered what the proportion between the weight of the projectile and the muzzle velocity shall be.

With increased weight of the projectile and unaltered caliber an increase of the length of the projectile and the powder pressure occurs. The first necessitates increasing the twist of rifling, also in connection with the latter, the strengthening of the shrapnel cases, which diminishes the available space. By increasing the twist of rifling, the velocity of revolution of the projectile is enhanced, endangering the uniform combustion of the füze and finally making the cone angle greater than is desirable.

In spite of increased sectional density, the conditions of the line of flight with lengthened projectile are not always improved, because the greater perturbations may increase the resistance of the air and diminish the accuracy of fire. It has even been experienced, at the moment of bursting, the axis of the projectile in some cases was not in the tangent to the trajectory and so the axis of the cone of dispersion did not coincide with the trajectory of the unexploded base-chamber shrapnel. The result of the experiments made is that a length of projectile of 4 diameters should be considered the limit for ordinary field projectile construction, and that it is even desirable to retain a length of about 3.6 diameters.

Tests made with various heavy projectiles have proved, as far as one may draw conclusions from single experiments, that a superiority of accuracy of fire of heavy projectiles over light ones or vice versa, with equal caliber, does not exist as long as these differences amount to no more than 8 to 10 per cent of the weight of the projectile, and it is a question of projectile length between

3.5 and 4 diameters. In all the guns experimented with the final angle of rifling was 7° 10′. It was nowhere too small, which was proved by the fact that all the shot holes in the target were circular.

A list of similarly constructed projectiles of a caliber to be considered for field guns, giving the approximate lengths and sectional density of projectiles is given in Table VIII.

TABLE VIII.—SIMILARLY CONSTRUCTED PROJECTILES.

	I		II		III		IV		V		VI		VII		VIII	IX
Caliber in inches	2.76		2.83		2.89		2.95		3.01		3.07		3.15		Approximate length of projectiles in diameters	Remarks.
Cross section, square inches	5.98		6.29		6.56		6.83		7.12		7.40		7.79			
No.	D.	G.	D.	G.	D.	G.	D.	G.	D.	G.	D.	G.	D.	G.		
1	....	....	....	....	9.96	1.51	10.58	1.54	11.02	1.55	11.90	1.60	12.83	1.64	2.9	D=weight of projectiles.
2	....	....	....	....	10.43	1.58	11.02	1.61	11.70	1.64	12.41	1.68	13.38	1.71	3.0	
3	....	....	10.40	1.65	10.91	1.66	11.46	1.67	12.19	1.71	12.92	1.74	13.91	1.78	3.1	
4	9.92	1.65	10.78	1.71	11.33	1.72	11.90	1.74	12.65	1.77	13.40	1.81	14.44	1.84	3.25	
5	10.29	1.72	11.20	1.78	11.77	1.79	12.34	1.80	13.11	1.84	13.89	1.87	14.99	1.91	3.4	G=weight of projectiles per sq. inch of base.
6	10.67	1.78	12.14	1.93	12.21	1.86	12.78	1.87	13.60	1.89	14.42	1.94	15.52	1.99	3.5	
7	11.02	1.84	11.99	1.90	12.60	1.92	13.23	1.93	14.06	1.97	14.9	2.00	16.05	2.06	3.6	
8	11.40	1.90	12.39	1.97	13.03	1.98	13.67	2.00	14.53	2.04	15.39	2.08	16.55	2.12	3.7	
9	11.77	1.96	12.78	2.03	13.45	2.05	14.11	2.06	14.99	2.10	15.87	2.14	....	....	3.8	
10	12.12	2.02	13.18	2.09	13.86	2.11	14.55	2.13	15.45	2.17	16.38	2.21	....	....	3.9	
11	12.50	2.09	13.58	2.15	14.28	2.17	14.99	2.19	15.94	2.24	....	....	....	....	4.0	
12	12.87	2.15	14.00	2.22	14.70	2.24	15.42	2.26	16.42	2.30	....	....	....	....	4.1	

The appropriate determination of the weight of projectiles of the field artillery has already been discussed. It is proper to reiterate here that the determination of the weight of projectile is the most important factor for the building of the whole system and for the conditions of recoil, inasmuch as, given the muzzle energy, it is by no means unimportant whether it is attained by a great weight of projectile or by a high muzzle velocity, because the weight of the projectile appears only in the first power, while the muzzle velocity is in the square in the expression of the muzzle energy, although both have the same influence on the velocity of recoil.

Besides the advantage of reduced rearward strain and velocity of recoil with given weight of material, the following advantages seem at first sight to speak in favor of small caliber : Range and terminal velocity are greater, the angles of fall smaller, the result expressed by the effectiveness of fire, based on uniform weight is more favorable, at least if the projectiles lost to effectiveness in correcting the range are counted in. The heavier weight of projectile has only apparently the advantage of greater single-fire efficiency, and one would think that this could be equalized by a greater number but equal total weight of lighter projectiles. If one examines the conditions more closely, the advantages of the heavy projectiles appear more clearly. The superiority of the lighter projectiles in regard to terminal velocity and angle of fall, at long range, as occurs principally in artillery action, is only unimportant (see Table IX). The drawbacks, however, which must be accepted with it, are not unimportant; the relation of the effective weight of shrapnel to the dead weight is less favorable (See Table VII); either the powder charge, or the gas pressure and the wear and tear of the gun increases, and in the first case the cartridge must be proportionately longer and heavier. The difference in the cartridge weight is not proportionate to the difference in the weight of the projectiles. The further consequences of the comparatively longer and heavier cartridge are apparent in the construction of the ammunition chests and wagons, inasmuch as the latter carry less weight of ammunition. The number of rounds which the gun and ammunition wagon ready for transportation carry is not in simply inverse ratio to the weight of projectiles, but is always less favorable for the lesser weight of projectile in the case of projectiles of the same type of construction and of equal muzzle velocity. The variations in time of burning become greater with the lighter projectiles and are considerably greater than with the heavy ones, as not only is the velocity increased, but also at the same time, in consequence of the smaller diameter, the rotary velocity, which influences unfavorably the regularity of burning of the fuze.

TABLE IX.—BALLISTIC CONDITIONS OF GUNS OF DIFFERENT CALIBERS WITH SIMILARLY CONSTRUCTED PROJECTILES. L. 3.6, FOR EQUAL MUZZLE ENERGY.

No.	I	II				III				IV				V
	Caliber, in inches	2.76				2.95				3.11				
	Weight of projectile, lbs.	11.02				13.23				15.43				
	Weight of projectile, per square inch of base	1.84				1.93				2.03				
	Muzzle energy, foot-tons	246.37				246.37				246.37				Remarks.
	Range.	Remaining velocity.	Angle of fall. Degrees and minutes		Angle of fall. Cotangent.	Remaining velocity.	Angle of fall. Degrees and minutes		Angle of fall. Cotangent.	Remaining velocity.	Angle of fall. Degrees and minutes		Angle of fall. Cotangent.	
	yards.	*feet.*	°	′		*feet.*	°	′		*feet.*	°	′		The cotangent indicates the distance covered per unit of length.
1	0.0	1,795	0	0	∞	1,640	0	0	∞	1,516	0	0	∞	
2	1,093.6	1,335	1	24	41	1,243	1	30	35	1,178	1	53	30	
3	2,187.2	1,066	4	6	14	1,030	4	33	12	1,004	4	56	11	
4	3,280.8	925	7	58	7.2	905	8	40	6,6	872	9	13	6.1	
5	4,374.4	824	13	11	4.3	810	18	58	4,0	800	14	37	3.8	
6	5,468.0	748	19	56	2.7	745	20	46	2,6	741	21	23	2.5	

If, therefore, the heavier projectile is to have the preference in general, on the other hand, the weight must not be increased so much but that the projectile can be given such a muzzle velocity that an effective shrapnel round will prove efficient at the longest range occuring on the battlefield. From the newer high development of shrapnel efficiency shown in Table VII, the limitations of extreme weight of projectile to 6.5 kg. with 250 to 280 balls, even for such heavy demands as European conditions require, are entirely sufficient. On the other hand, according to the preceding explanations, it is to be recommended that the lowest limit of weight should not be under 5.5 kg. Whether one inclines more to the lower, 5.5 kg., or to the higher, 6.5 kg., limit of weight depends first upon the admissible weight of the limbered gun, which is determined by conditions which belong in the domain of the tactician. If the latter demands extreme mobility of the gun, with inferior horse-flesh, or if the prospective seat of war offers bad roads and poor topographical conditions, or if the enemy is less well drilled and equipped, it is only natural that the weight of projectile should be kept under the afore-mentioned limit and that even the muzzle velocity of 500 m. should be reduced according to circumstances.

If the muzzle velocity, independent of the weight of projectile and the muzzle energy obtained in connection therewith, is considered, the same result is reached, viz., that an increase of muzzle velocity beyond 500 m. (1,640 feet per second) is superfluous and under some circumstances harmful.

Such an increase, the advantages of which are only slight for the terminal velocity and angle of fall (for example see Table X), has decided drawbacks; as the strain of the material and the conditions of recoil are much less favorable with an increased muzzle velocity, in order to counteract this the material must be made heavier, which extends in the first place to the unlimbered gun and in the second place to the limbered piece, because the cartridge and therewith also the loaded limber become heavier for the increased muzzle velocity. To hold to the example given in Table X, this can be demonstrated by the following figures (under supposition that in both guns the number of rounds carried in the limber is equal and that the carriage strain and velocity of recoil of both pieces are similar):

Weight of projectile	kg..	6.35	6.35
Muzzle velocity	m..	500	560
Weight of cartridge	kg..	8	8.4
Weight of unlimbered gun	kg..	880	1,000
Weight of limbered gun	kg..	1,680	1,820

A comparison of the data, which illustrates the constructions referred to, shows that these figures are actual. Therefore to attain an increase of terminal velocity of 14 m. on a range of

3,000 m. and a reduction of just 1 degree in the angle of fall, it is necessary to increase the weight of the limbered gun 140 kg., and finally, if at least about the same carriage strain and velocity of recoil are retained, a greater strain on the gun and also increased wear and tear must be incurred. The small advantages are too dearly bought. If on the contrary the weight of the gun was increased by less than 140 kg., the result would be greater strain of carriage, greater recoil; and therefore an unsteady working of the gun with all its consequences, increased difficulties of manipulation, reduction of the rapidity of fire, and, under some conditions, less accuracy of aim.

TABLE X.—BALLISTIC CONDITIONS OF TWO 2.9528-INCH GUNS WITH EQUAL WEIGHT OF PROJECTILE, BUT WITH DIFFERENT MUZZLE VELOCITIES.

	I	II			IV			IV
	Caliber in inches	2.95			2.95			
	Weight of projectile, pounds	14			14			
	Weight of projectile, per sq. in of base	2.048			2.048			
	Muzzle energy, foot-tons	261.55			326.13			
No.	Range.	Velocity.	Angle of fall. Degrees and minutes	Angle of fall. Cotangent.	Velocity.	Angle of fall. Degrees and minutes	Angle of fall. Cotangent.	Remarks.
	yards.	*feet.*	° ′		*feet.*	° ′		
1	0°	1,640	0 0	∞	1,837	0 0	∞	The cotangent indicates the distance covered per unit of height.
2	1,093.6	1,263	1 37	35	1,407	1 17	44	
3	2,187.2	1,047	4 25	13	1,119	3 42	15	
4	3,280.8	925	8 23	6.8	971	7 18	7.8	
5	4,374.4	833	13 24	4.2	869	11 55	4.7	
6	5,468.0	764	19 47	2.8	791	17 48	3.1	

RAPIDITY OF FIRE, ACCURACY OF FIRE, AND GENERAL EFFICIENCY.

Reports of the rapidity of fire are to be found in the different records and test-firings already mentioned. These show that even under unfavorable conditions a single gun can discharge five or six well-aimed rapid-fire rounds a minute, and the rapidity of fire under favorable conditions can be brought up to eight rounds, and with canister to even double this number. The results of the tests show how much the accuracy of fire suffered in some of the tests from the rapidity of fire. The difference between slow and rapid fire for the mean deviation, with a discharge of six or seven rounds per minute, according to one of the tests, amounts to 10 per cent in height. The same increase, that is, 10 per cent of the mean deviation in height, was established by another test. A contrary result, that is, a marked improvement in deviatión, occured in a test firing with a muzzle velocity of 460 m. and a weight of projectile of 6.5 kg., from a 7.5-cm. rapid-fire gun, L. 28, at a range of 1,000 m. The rapidity was a trifle greater than before, viz, seven or eight rounds a minute. The mean vertical deviations were 6½ per cent and the mean horizontal deviations 17½ per cent less than with slow fire. During this firing a strong wind (7 m. a second) was blowing from the left and rear. The greater rapidity of fire may have been in this instance so far favorable, as all rounds were fired consecutively under similar, although unfavorable, meteorological conditions. Especially remarkable was the diminished accuracy of fire which appeared in a test made with a gun which was light in comparison to its muzzle energy, and was therefore unsteady. Another comparative test, at a range of 2,500 m., resulted, like one previously mentioned, more favorably for rapid fire, although no diminution of the mean deviation occurred, as in the previous case, but only a slight increase thereof. A test of slow firing was made with the same gun in which once the sighting device was fixed immovably. No brake was used, consequently it was fired in the same manner as were the obsolete field guns. The second time the brake and sighting device were both applied. The various rapid-fire tests of accuracy of fire have practically demonstrated what was to be expected from theoretical considerations, viz, that in general increased rapidity of fire diminishes the accuracy of fire. They can serve as a warning against rapid fire and prove that it is a mistake to make the number of rounds the sole comparative argument for judging rapid-fire field guns. For the discussion of the accuracy of fire in slow firing a few more tests may be mentioned. Besides those of the usual distance of 1,000 m., others at greater and in some instances very long ranges or with very large number of rounds were made.

That the values of accuracy of fire obtained from rapid fire considered by themselves are satisfactory is shown not only by the tests last mentioned, but also by numerous others, carried out for other purposes and already discussed.

Much firing for testing the effect has been carried out with time fuzes against field objects. The effective rapid-fire tests give interesting points as to what can be attained under peaceful conditions, in a short time, with increased rapidity of fire. This consideration is the more important that in war practice it is not so much a question of obtaining an unlimited effectiveness as to achieve in a very short time a sufficiently great result.

Publication authorized by the Secretary of War:

A. R. Buffington,
Brigadier General, Chief of Ordnance.

Ordnance Office,
Washington, April 13, 1900.

THE 16-INCH BREECH-LOADING RIFLE,
TYPE, MODEL 1895.*

REPORT BY COLONEL J. P. FARLEY, ORDNANCE DEPARTMENT, UNITED STATES ARMY, DATED WATERLVLIET ARSENAL, WATERVLIET, N. Y., SEPTEMBER 15, 1900.

NOTES ON THE CONSTRUCTION OF ORDNANCE.

Washington, November 27, 1900.

(Concluded).

MEASURING INSTRUMENTS.

MEASURING POINT (Fig. A).

Measuring points for obtaining inside diametrical measurements of hoops, etc. (where it is not practicable to star guage), consist, as shown in sketch, of an extension piece, *a*, made of wood, on each end of which a steel thimble is screwed, one thimble carrying a fixed or adjusting point, *b*, and the other a micrometer point, *c*, same as in case of caliper arm. In adjusting this point it is necessary to set it to the desired length in inches either in the shop comparator or vernier scale, and then obtain the variations in hundredths and thousandths by reading the micrometer point. This point has been found very reliable and does not change from handling as much as those of other makes; and after being carefully set, a great number of measurements can be safely taken without fear of alteration. This point can be used for any size, is easily and quickly put together, it being of course necessary to have extension pieces varying in length by 5 inches, the length of the fixed steel point.

MICROMETER FOR SURFACE LENGTHS (Fig. A).

This instrument is used for measuring the distance between two center punch marks on the exterior of a hoop or jacket, before and after shrinkage, to determine the change due to such shrinkage. It consists of a beam, *D*, which carries a slide, *E*, with a micrometer point, and a fixed support, *L*, having a fixed point, *b*. There is a reference bar, Fig. 6, for use in setting this instrument, having center punch marks 1 inch apart, by means of which it can be set to any desired length in even inches. After the instrument has been adjusted to the desired length, punch marks are made in the piece to be measured and the distance between the marks taken, the variation from the even inches read by the micrometer. In using this instrument care should be taken to have the punch marks on the piece to be measured less tapering than the measuring points of the instrument, so as to insure contact at the top rather than at the bottom of the punch marks on the piece, and thus do away with any possible play.

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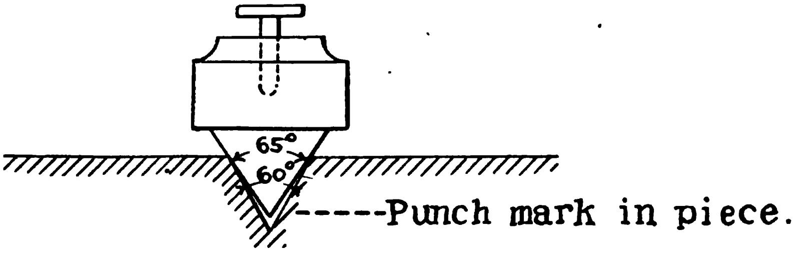

CALIPER ARMS (Fig. A).

The caliper arms used at this arsenal were made at Watertown Arsenal, and consist of a steel frame lagged with wood, having sockets, *a a*, for clamping the fixed point *b* and the micrometer point *c*, which has a micrometer head graduated to read to $\frac{1}{1000}$ of an inch. The method of using these calipers is to suspend a caliper arm of the capacity needed, insert and clamp the fixed and micrometer points, and set same to zero from a measuring point previously adjusted to the required even inches either in the comparator or vernier scale; then get the variation in hundredths and thousandths by reading the caliper micrometer head. This style of caliper is used in making all exterior measurements, such as shrinkage surfaces for hoops, jackets, etc. Provision has been made to suspend these caliper arms over the work to be measured, and thus relieve the operator of the weight, etc., but this method has not been found necessary here, the operator using the caliper in about the same manner as the workman used his guage in doing the necessary measuring for the performance of his work. It is of the greatest importance to hold the caliper in the same position when setting it as when measuring with it, in order that the sag may be the same in both cases.

SHOP COMPARATOR (Fig. B).

This is an instrument designed by a board of ordnance officers, and made at Watertown Arsenal.

It is used for making measurements where it is desired to determine sizes within a smaller limit than $\frac{1}{1000}$ of an inch. It consists of a bed, *a*, supported by a solid foundation to prevent jar; sliding heads *b* and *c*, carrying the measuring points *e e*, between which the object to be measured is placed; also an auxiliary carriage, *d*, used for adjustment, a microscope, *F*, having a screw micrometer, *G*, which admits of dividing the spaces on the graduated bar in bed *a* into $\frac{1}{10000}$ of an inch.

TO OPERATE COMPARATOR.

The graduated bar being in in its recess, and the points *e e* in contact, the bar and microscope are adjusted so that the zero line in microscope *F* coincides with zero of the graduation on the bar. To lay off a given length the head *b* being in place and clamped, move the head *c* until the microscope stands ovor the nearest desired division of the bar, then move the microscope by use of adjusting screws *H H* and screw micrometer *G* until the desired thousandths and ten thousandths are obtained, then move the head *c* to the mark representing the desired number of inches on the bar.

CONCENTRICITY GAUGE (Fig. C).

This instrument was designed and made at Watervliet Arsenal. It is used to ascertain whether or not the powder chamber and main bore of a gun are concentric, and, if not, measure the amount of eccentricity. It also measures the length from breech end of tube to that point on the connecting slope (between main bore and powder chamber) where the shot sabot makes contact.

.It also measures the size of the gas-check seat and the depth of the rifling grooves.

The body of the gauge on the ground surfaces *a a* is 0.003 inch smaller than the powder chamber in which it rests. By using the four measuring rods *b b b b*, which have micrometer readings on their handles *c c c c*, and measuring points at their forward end *D*, four measurements are readily obtained in the main bore of the gun, which would all be the same provided powder chamber and main bore were concentric. The gauge has at its rear end a gauge, *E*, for the gas-check seat, and a guage, *F*, which gives length from end of tube (shown by dotted line *G*) to sabot seat.

There are marks *H H* on the rods attached to these gauges *E* and *F*, which, when all dimensions are correct, come flush with the rear of the gauge *K*; any departure therefrom being readily measured by a small scale.

STAR GAUGE (Fig. D).

An instrument made at Frankford Arsenal and used for measuring the bores of guns when finished and the preliminary bores during construction of gun to ascertain amount of compression caused by assembling different sets of hoops, etc.; also to obtain the interior diameters of hoops, jackets, etc,, up to any diameter for which star gauge points have been provided.

The principal parts are the head *a*, staff *b*, and the handle *c*, which latter carries a micrometer head, *d*, graduated to read $\frac{1}{1000}$ of an inch. The method of using the star gauge consists in putting in the proper measuring points, *E E E E*, in the sockets in the head and adjusting them to a ring of desired size, *F*, until the micrometer reads zero. The gauge when in use is supported by a rest, *G*, to keep it in the axis of the bore. In star gauging the rifling grooves three points are used 120° apart, and the points are kept in the grooves by a suitable rifling guide attached to the head of gauge. The head is arranged to revolve with the rifling so that the micrometer handle may remain constantly in view and be easily read. The points of the gauge are moved by a cone attached to a rod running through the entire length of the staff, and to which the micrometer head is connected. The points are extended by revolving micrometer head to the right, and withdrawn by revolving to the left.

ELECTRIC CRANES.

120-TON ELECTRIC CRANE.

This crane was manufactured by the Morgan Engineering Company, Alliance, Ohio. It is equipped with one Thomson & Houston shunt-wound 220-volt motor. This motor runs at a speed of about 1,000 revolutions per minute, requiring about 80 amperes when under full load. The different movements of the crane are controlled by shafting geared to motor, one motor doing all the work. The power to operate motor is taken from six single wires about 00 size, lying alongside and on each side of crane track. The wires are stretched and held in place by long composition rods, threaded on one end, fastened to each wire, and set up with nuts on each end of wire.

EQUIPMENT OF CRANE.

There is one starting box for motor, one Western ampere meter, and one Western volt-meter.

60-TON ELECTRIC CRANE.

This crane was manufactured by the Shaw Electric Crane Company, of Muskegon, Mich., and is provided with four series motors, one for each movement of the crane.

MAIN HOIST MOTOR.

This motor is a 75-horsepower motor of the multipolar type, made by the E. G. Bernard Company, of Troy, N. Y.; it has a series and a shunt winding on field coils, the shunt winding being placed on motor fields to check the speed of the armature when lightly loaded. The speed of this motor is controlled by the operator and without risk of burning out rheostat coils, as is the case with other starting boxes if partly thrown out.

The Brake.

The brake is controlled by two solenoids, connected in series with motor circuit, working in opposition to springs, and is automatic in operation; that is, when current enough to lift brake has been applied, brake is released and motor starts to lower or hoist, as the case may be. To lift a 12-inch gun, completed, requires about 160 to 170 amperes.

Auxiliary Hoist Motor.

This hoist was furnished by manufacturer of crane. It is rated at 20 horsepower, at about 250 revolutions. The brake on this hoist is of the same general design, and is connected and works in the same manner as brake on main hoist.

Trolley Motor.

This motor was furnished by manufacturer of crane. Its function is to move the car on the crane in an east or west direction. Rated by makers at 9½ horsepower at about 300 revolutions per minute. It is of same design as auxiliary hoist and bridge motors.

Bridge Motor.

This motor was furnished by maker of crane, its function being to move the crane north or south on the crane track. Rated by maker at 20 horsepower at about 250 revolutions per minute. It is of same design as trolley motor.

Equipment of Train.

There are four starting boxes located in cage of crane and operated by levers in the hands of the operator. These starting boxes are side by side on west side of cage. Three automatic circuit breakers, one on the main line set at 250 amperes; one on trolley circuit, to prevent car from running over too far, east or west; one on bridge circuit, which opens when car comes too close to either of other cranes; one ground detector, one Weston ampere meter and one Weston voltmeter.

16-INCH B. L. RIFLE TURNING AND BORING LATHES.

The 16-inch turning and boring lathes consist of the bed, headstock, two tool carriages; muzzle, intermediate and breech back rests, and boring bar with carriage. The bed is composed of parts as follows: The headstock end 23 feet 4 inches by 9 feet 10 inches wide, a single casting; the remainder of main bed is in two sections, each a single casting 22 feet 4 inches long and 9 feet 10 inches wide; the boring-bar carriage bed is in three sections, each a single casting 22 feet 4 inches long and 6 feet wide. The total length of the bed is thus 135 feet. All sections of bed are held together by means of taper bolts.

The headstock carries three spindles, the main, cone, and back-gear spindles; single gearing ratio is 1 to 54, compound gearing ratio is 1 to 384. The front end of main spindle carries the face plate, 9 feet 2 inches in diameter, and with eight chuck jaws of cast steel, taking in diameters between limits of 18 and 67 inches.

The tool carriages, of which there are two, consist of the lower, lateral slide capable of traveling the length of main bed by means of feed screw or by ratchet wrench; on this slide is the lower cross slide, on the lower cross slide is the swivel slide, on the swivel is the intermediate cross slide, and on the intermediate cross slide are the two upper cross slides, with which the turning tools are fastened in. The feeds to operate these rests are taken from the back gear spindle, through change gears to lead screw and spline rod, which rod engages with lower lateral slide by means of bevel gears.

Back rests, of which there are three; two of these rests are ring rests, one to be used at the center of gun, the other at muzzle; the third rest is a dead rest and is used at breech end of gun after gun is fully assembled. These rests are moved along the bed by ratchet wrench, and they are fastened to bed by bolts in T slots in bed.

Boring-bar carriage is mounted on bed and bolted to the latter by bolts in T slots which run the entire length of lathe bed; the sections of carriage are bolted together with taper bolts, a housing carrying gearing for conveying feed motion to the boring bar, and pulleys for rapidly moving the boring bar, are bolted to rear end of carriage. The boring bar is of forged steel, 61 feet long by 11 inches diameter, with 7-inch hole extending its entire length; it is made in two pieces coupled together securely. It is supported by five housings; the rear housing has a nut which engages in feed screw; the feed screw is driven from gear on main spindle of head stock through change gearing to shaft running entire length of lathe.

NOTES IN REFERENCE TO THE MANUFACTURE OF STEEL FORGINGS FOR 16-INCH GUN, UNITED STATES ARMY.

TUBE.

The tube was made from a nickel-steel ingot, octagon in section, weighing about 100 tons. The ingot was cast from the product of three open-hearth furnaces.* A discard of about 44 tons was cut from the top of this ingot and about 8 tons from the bottom of the ingot, leaving a block 188 inches long, octagonal in section, which was used to make the tube forging.

A hole was bored longitudinally through the axis of this block, after which the block weighed about 50 tons. From this block the tube was forged hollow on a mandrel under a 14,000-ton hydraulic press; the forging being of sufficient total length to provide the necessary test metal.

The completed forging was passed to the machine shop, where it was rough-turned and bored over its entire length, including the extra length for testing. The tube as rough-machined was next submitted to treatment in order to give the metal the necessary physical qualities. The treatment consists of tempering—that is, hardening in oil and annealing.

Physical qualities.—Four specimens 0.564 inch in diameter and 3 inches long between measuring points were cut from each end of the tube and showed the following physical qualities:

Elastic limit	51,375 pounds per square inch.
Tensile strength	84,350 pounds per square inch.
Elongation	20.38 per cent.
Contraction	41.93 per cent.

JACKET.

The ingot used for the jacket was also of nickel steel, octagon in section and weighed about 245,000 pounds, being cast from the product of three open-hearth furnaces. A block was cut from this ingot of the necessary weight to form the jacket, together with the test metal, and a longitudinal axial hole was bored through the block. From this block the jacket was forged on mandrels under a hydraulic press. It was then passed to the machine shop and rough-bored and turned preparatory to treatment.

The treatment or tempering was similar to that of the tube, consisting of tempering in oil and annealing.

Physical qualities.—Eight specimens 0.564 inch in diameter and 3 inches long between measuring points (4 from each end) were cut from the prolongation of the jacket and showed the following average physical qualities:

Elastic limit	52,250 pounds per square inch.
Tensile strength	87,800 pounds per square inch.
Elongation	22.16 per cent.
Contraction	48.32 per cent.

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* The metal for tube and jacket was not fluid compressed-steel.

HOOPS.

The hoops were made of simple fluid-compressed steel, containing no nickel. The ingots were cast round in section, and were cut in a lathe transversely into blocks of suitable weight to make the hoops, together with extra metal for testing. Longitudinal axial holes were bored through the blocks, which were then ready for forging. After heating, the blocks were forged on mandrels under a hydraulic press to the dimensions required.

While in the case of tubes and jackets the forging is elongated on a mandrel to get the required length, in the case of hoops (owing to the shorter length and greater inside diameter required) the blocks are for the most part enlarged on a mandrel supported at both ends, in order to increase the diameter of the hole. After forging, the hoops—like the tube and jacket—are submitted to treatment, which consists of tempering and annealing, performed under such conditions as to give the desired qualities.

It should be noted that, in general, the hoops are made of a harder steel than tubes and jackets—that is, the elastic limit and tensile strength are greater. The following are the average physical qualities obtained from the hoops of the gun in question.

Elastic limit	57,125 pounds per square inch.
Tensile strength	107,050 pounds per square inch.
Elongation	19.28 per cent.
Contraction	45.52 per cent.

For the above information the writer is indebted to Capt. C. L'H. Ruggles, Ordnance Department, U. S. A., inspector at Bethlehem Steel Company.

TIME OF PRINCIPAL OPERATIONS.

[Items marked (*) are completed and show actual time. Items not so marked are estimated. No allowance is made for accidents, delays, etc.]

	Days.
Rough-bore tube (hognose)	*56
Rough-bore tube (reamer)	*13
Rough-turn shrinkage surface for C hoops	*16
Finish-turn shrinkage surface for C hoops	*18
Assemble C 1 and C 2 hoops	*5
Rough-turn shrinkage surface for jacket	*11
Finish-turn shrinkage surface for jacket	*12
Assemble jacket (first trial, 11 days; second trial, 4 days)	*15
Rough-turn shrinkage surface for D hoop	*16
Finish-turn shrinkage furface for D hoop	*8
Assemble D hoop	*5
Rough-turn shrinkage surface for A hoop	*14
Finish-turn shrinkage surface for A hoop	*24
Assemble A hoops (A 1 and A 2, 2 days; A 3, 2 days)	*4
Rough-turn shrinkage surface for B hoop	*12
Rough-turn shrinkage surface for B hoop (second cut)	9

	Days.
Finish-turn shrinkage suaface for B hoops	9
Assemble B hoops	6
Telltale and counterbore for first reamer for finish boring	*12
Bore (first reamer, to 15.6 inches in diameter)	*16
Bore (second reamer, to 15.8 inches in diameter)	*16
Finish bore (fourth reamer, to 16 inches diameter)	16
Bore powder chamber (first hognose)	10
Bore powder chamber (second hognose)	10
Bore powder chamber (reamer)	12
Ream centering slope (conical reamer)	6
Finish tread box and gas-cheak seat	6
Finish-turn exterior	20
Rifle	48
Ream forcing slope (conical reamer)	4
Cut muzzle to length	6
Drill for and insert securing pins	5
Thread	14
Slot	14
Mill for hinge	10
Mill for hinge (and tap holes)	4
Finish threads	14
Assemble breech mechanism	10
Mark, weigh, and paint	5
	527
Transportation, etc.	33
Estimated total	560

PRINCIPAL OPERATIONS UPON JACKET AND HOOPS.

The following operations, together with all work upon breech mechanism, is calculated to be completed by the time the respective parts are required for assembling on the gun; while affecting output they do not affect the time required to build a particular gun:

Jacket:	Days.
Rough bore (hognose)	90
Ream (first reamer)	20
Ream (second reamer)	20
(Entire exterior rough-turned, and lip for D hoop formed during first and second reaming).	
C 1 hoop, rough and finish bore, including lip	63
C 2 hoop, rough and finish bore, including lip	47
D hoop, rough and finish bore, including lip for A 1 hoop	62
A 1 hoop, rough and finish bore, including lip for B 1 hoop	59
A 2 hoop, rough and finish bore	31
A 3 hoop, rough and finish bore	35
B 1 hoop, rough and finish bore	30
B 2 hoop, rough and finish bore	40
B 3 hoop, rough and finish bore	40

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A. R. Buffington,
Brigadier General, Chief of Ordnance.

Ordnance Office,
Washington, November 27, 1900.

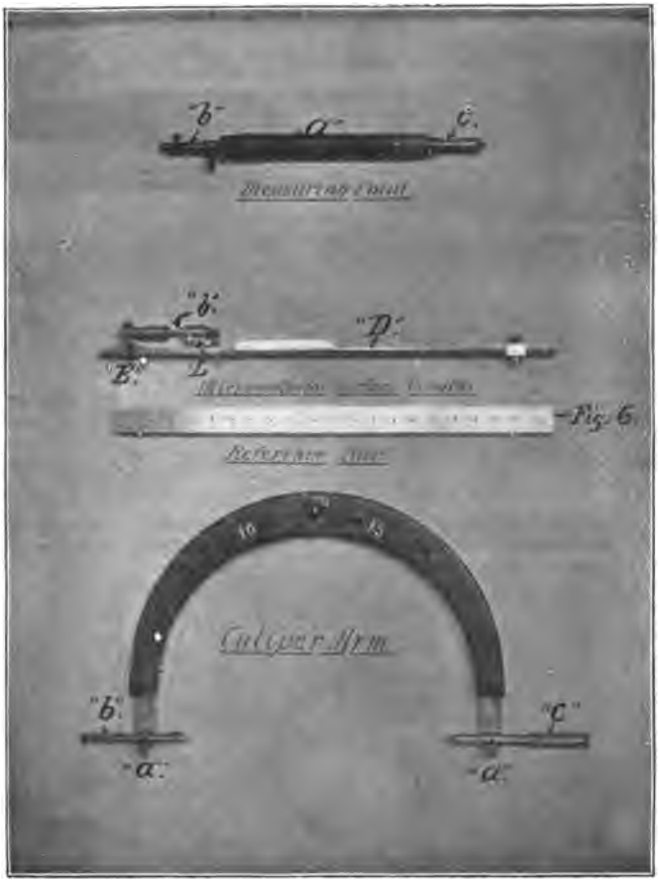

"b"
"a"
"c."
"b"
"C"
"D"
"B"
L
Fig. 6
Reference Bar
10
15
Caliper Arm
"b"
"C"
"a"
"a"

Fig. A.

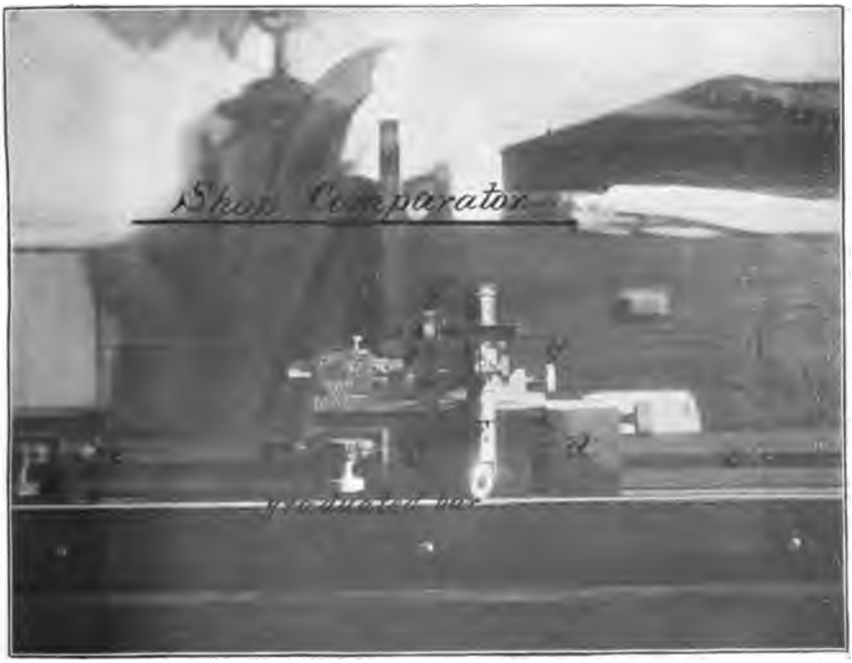
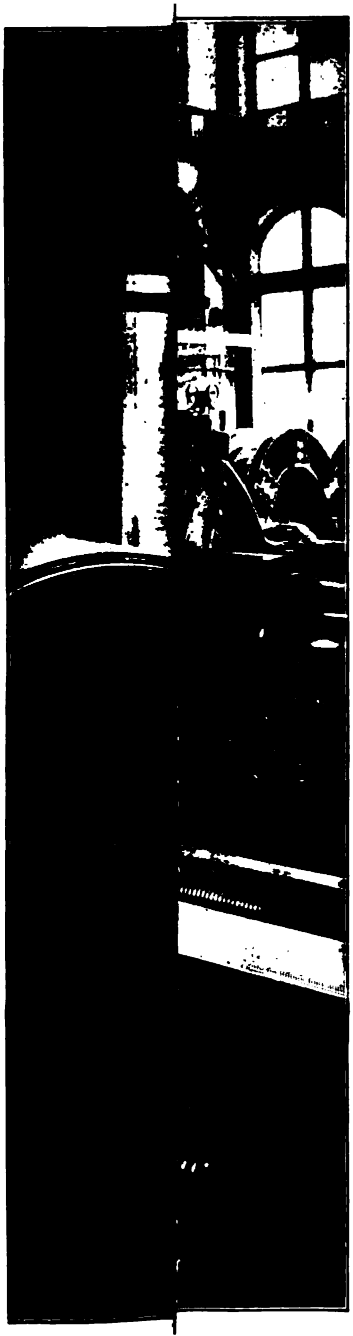

Shop Comparator
a
graduated bar

Fig. B.



THE STUDY OF SEA-POWER.

D. Bonamico.

Reprinted from *Marine Rundschau.*

(Concluded).

B. THE STUDY OF THE EXTERNAL DYNAMICS OF SEA-POWER.

The study of sea-power would not be complete if that of its internal dynamics were not followed by that of its external. The latter study comprises all the motion events which strive to attain the aims of sea-power upon the international domain.

After having determined the order of the aims and the means and systems of expansion, we pass to the investigation of the historical methods which developed them and to the establishment of the principles which governed expansion in the past and will continue to do so in the future.

The motion event may be divided into preliminary and decisive parts. The preliminary part includes, particularly, superiority of commerce, science and politics, by which a title may be established for justifying the expansion in case its introduction is considered favorable.

Decisive superiority furnishes a title for the attainment of protectorship or dominion and always requires the cooperation of the active force. Though this superiority may often be attained through diplomatic negotiations, it yet always makes conflicts very probable, so that decisive superiority may always be regarded as the prerogative of the active force.

The lesser importance of the preliminary steps and their too variable characteristics, relieve us from the obligation to investigate the principles of their capricious motion. We nevertheless refer to the fact, that these preliminary steps may often acquire a very important influence during the first part of the expansive motion, as, for example, in India and Egypt.

Let our investigations be restricted, therefore, to the decisive superiority, namely, the security of the title, without whose statical or dynamical efficiency, the attainment and maintenance of the aim of expansion is impossible.

Universal history indicates the following as the decisive events which assure immunity at sea:

a. The military occupation of the country constituting the aim of the expansive efforts, or of that of its provision centers.

b. The crippling of the enemy's active forces in order to have a free field for attainment or maintenance of the aim.

c. The pure naval war, for the attainment of the free dominion of the sea.

d. The destruction of commerce, for the exhaustion of the enemy's vitality.

These four decisive events represent the four principal systems of warfare which, since the beginning of the world's history, have been employed by nations for the attainment of their own aims or for preventing the accomplishment of its aims by the enemy.

They constitute, therefore, the subject matter of the external dynamics of sea-power whose principle we are investigating for the completion of the study already developed.

It is not our purpose, in the investigation of the military dynamics of sea-power, to enter the military-scientific domain, and particularly not that of strategy, so far as the latter is directly connected with the employment of sea-power. We will investigate only those general principles which relate, not to the technics of naval warfare, but rather to the economic employment of the motion, and consequently in the domain of the general formation of a relatively sea-faring nation.

The principles which we will adduce upon the four principal kinds of warfare may be regarded as an introduction to naval strategy and should constitute, therefore, an essential part of the study of sea-power.

a. THE MILITARY OCCUPATION OF THE ENEMY'S COUNTRY.

This is the most efficient and decisive kind of naval warfare and is directed towards the immediate attainment of the aim of expansion, which is territorial acquisition.

The occupation of the enemy's country almost always presupposes an adequate if not absolute possession of the sea, an adequate expansive force and a ruling power competent for the accomplishment and maintenance of territorial acquisition.

When these preliminary conditions are not all fulfilled to the extent demanded by the character of the object and the international position, little hope exists of bringing the undertaking to a happy issue, even though begun under favorable auspices. We assume, therefore, in adducing the principles which govern the conduct of the first kind of naval warfare, that the preliminary conditions relative to the sea and land power and to the national expansive capacity are satisfactorily fulfilled.

The principles governing the employment of sea-power in a war which aims at the partial or total occupation of the enemy's territory seem to be as follows:

1. The occupation of the enemy's territory is the most definite measure of motion, since it permits the greatest and most enduring retirement of the enemy.

2. This mode of action should always be selected, if possible, after the means for doing so have been politically prepared.

3. In time of galley fleets, sea war, owing to the strict dependence of fleets upon their fortified points of support, was almost exclusively a struggle for the occupation of the enemy's territory, which was almost always regarded as the primary and direct problem.

4. This mode of warfare is more prominent than other kinds, the more fleets are lacking in military character and self dependence, and the more they serve simply as military transport.

5. The galley fleets of ancient times followed this mode of warfare more than those of the middle ages; sailing fleets, on the contrary, abandoned this method entirely, whilst modern fleets seem to favor a return to the methods of ancient times.

6. The waging of this mode of warfare by modern fleets presupposes the supremacy of the sea, an adequate expansive capacity and the cooperation of the land power.

7. These three conditions must be fulfilled if the occupation of the country is to succeed, since without expansive strength it can not be hoped to long remain in possession of the country, and without the supremacy of the sea and the cooperation of the land troops the initial occupation can not be accomplished.

8. The mutual relation between the land and sea-power, is, therefore, the foundation of this mode of warfare; the interpretation of the motion depends, therefore, upon the laws which this mutual relation governs.

9. The presupposition of naval supremacy is the more indispensable, the more numerous are the land active forces necessary for the undertaking, and the more their maintenance depends upon the naval communications.

10. Great wars of invasion presuppose unconditioned naval supremacy; inadequate domination of the sea threatens the undertaking with serious misfortune.

11. The domination of the sea derived from blockading the enemy's fleet does not present sufficient protection for a great landing, since the blockaded fleet continues in a military and moral condition for breaking the blockade.

12. The attempt to accomplish the undertaking by eluding

the vigilance of the enemy's fleet, which may gain the upper hand, even if at first successful, is almost always fraught with disaster, if the landed troops can not make themselves independent of the maritime base.

13. In great landing undertakings, fortune smiles but rarely upon the daring leaders who abandon the principles pertaining to the sea.

14. The surprising of the convoy either during passage or while disembarking, threatens the undertaking with immediate disaster; the vulnerability of the base line and the lines of operation menaces the isolated landing corps no less seriously, even if the consequences are more remote.

15. Subordinate undertakings avoid immediate threats more easily than do great ones; they rarely, however, shake off the effects of a powerful naval dominion of the enemy.

16. The naval supremacy is incomplete and the injury postponed if the former is not supported by permanent or temporary points of support which, being favorably situated in the basins of operations, permit the most effective employment of the dominating fleet.

17. The number of these points of support depends upon the character of the active forces and upon the geographical situation; it may be assumed that an increase in the independence of the fleet is always more advantageous than a multiplication of the possible point of support.

18. The military points of support of the offensive should be capable of protection by the fleet and should not be exposed to attack from the land sides. Islands are, therefore, maritime fortresses, preference being given to small over large, and to isolated over those adjacent to continents, under the assumption, however, that they answer the requirements relative to service instruction and re-equipment.

19. The military points of support of the offensive should be temporarily fortified against surprises; this precaution should not be neglected even if surprises have but little probability of occurring.

20. The occupation of countries of great extent is only maintained with difficulty by the control of the sea alone; in such a case the internal organization presents a greater protection for the maintenance of the occupation.

21. The political and military organization of a great possession does not prevent unfavorable changes inevitably arising from the loss of naval supremacy.

22. The influence of naval supremacy upon land operations, offensive as well as defensive, is almost always decisive, notwithstanding that it is frequently but indirectly applied and eludes superficial estimation.

23. The effect of naval supremacy is mostly strategical, though it may also be tactical. The following effects merit enumeration:

(a). Supremacy at sea gives the land active forces complete freedom of action and independence.

(b). It holds the coast zone in its power, protects the disembarkation and guarantees protection to the troops in deploying and marching.

(c). It assures the subsistence of the troops and secures their retreat in case of a counter attack.

(d). It permits rapid maneuvering upon the theater of war.

(e). It hampers and cripples the activity of the enemy.

(f). It favors flank attacks at different points of the theater of war and holds in check a force of the enemy corresponding to that which may be disembarked in the flank attack.

(g). It permits the operation on inner lines and compels the enemy to operate on external ones.

(h). It secures the movement of the land force in the most effective and economical manner.

24. In practice, the influence of naval supremacy, owing to inadequate mutual understanding between the land and sea power, is almost always less than theory would lead us to expect.

b. THE CRIPPLING OF THE ENEMY.

The second kind of naval warfare does not aim directly and chiefly at the occupation of the enemy's territory, but primarily at keeping the opposing fleet at a distance from the theater of war.

This method of crippling, which may seem less effective and decisive than the method which aims directly at the overthrow of the enemy in sea battle, appears, to the historical investigator, not only as difficult of accomplishment, but also as rich in results.

The system of crippling destroys and enervates a fleet morally and militarily, perhaps more than defeat in battle.

A fleet which is overcome by moral dejection recovers with difficulty; a defeated fleet bears up through the simple fact that it has fought,—the vital strength for its revival.

From these and other grounds we hold that the method of crippling, if it can be effectively applied to the attainment of naval supremacy, is entitled to precedence over the other methods.

The principles which govern the application of this system of naval warfare appear to be as follows:

1. The method of naval warfare involving the crippling of the enemy's active forces aims directly at the enemy's fleet, which is capable of disputing the naval supremacy.

2. This method of war, if it can be effectively applied, must be given the preference to the other methods for the attainment of naval supremacy, since it causes a greater moral and military discouragement of a fleet than is caused by the loss of battle.

3. The method of crippling has sufficed in the past and will also suffice in the future for the protection of the most vulnerable sea interests.

4. The employment of this system is the more urgently demanded, the more the nature of the theater of war permits the enemy to threaten the sea interests from the closest proximity and most secure position.

5. This system is indispensable when the sea interests are large, scattered and easily vulnerable, constituting a nerve of life; if the provacation prove to be insufficient, the enemy is to be forced to fight.

6. The fleet which attains its aim without the use of its fighting resources does not prejudice its honor by avoiding battle.

7. The employment of the method of crippling depends upon the varied degree of efficiency of the blockade.

8. The blockade does not, it is true, aim at the hermetical closing of all the outlets, which has been and still continues to be impossible, but should, however, prevent the enemy's active forces, in whole or in part, from attaining such a condition of preparation as would enable them to undertake the accomplishment of a determinate problem.

9. The efficiency of a blockade depends upon the character of the fleets and upon the situation of the theater of war.

10. The qualities which render a blockade most efficient are able seamanship, great safety in maneuvering, very great independence and economical employment of the blockading active forces.

11. Blockades are favored by such theaters of war as permit the concentration of the blockading fleet and restrict to a minimum the harbors useful to the enemy, by great distances between the several inlets of the sea and by favorable meteorological conditions.

12. Galley fleets were not adapted for blockading, so that the method of crippling was only used exceptionally and almost always with slight effect.

13. In spite of their small maneuvering capacity, sailing fleets were exceptionally fitted for blockading service; consequently this system was frequently employed with advantage.

14. Cruisers at great intervals, in combination with advise and guard boats in the vicinity of the coast, constituted the blockade system of the sailing fleet, which was thus, nearly independent of a base of operations in the blockaded zone.

15. Although steam fleets are less independent and economical than sailing fleets, they are still greatly fitted for blockading service; it is difficult, however, to determine whether they are as well adapted for this purpose as are sailing fleets.

16. The accomplishment of a blockade by steam fleets can no longer be entrusted to cruisers at great intervals, but the fleet must either keep constantly on the move or within certain positions in the blockading sphere.

17. The waste of material, physical and intellectual forces occasioned by modern blockades is certainly not less than in the time of sailing fleets.

18. What steamships have gained in fitness for blockade breaking, they have lost in perseverance for the accomplishment of their strategical problems or for cruising wars (commerce destroying.)*

19. Favorable strategical and tactical positions within its base of operations offer the greatest protection to the blockaded fleet.

20. Large bases of operations with good storm protected inner bays, channels to the high seas and good means for landing and reconnoitering, are difficult to blockade and give the blockaded fleet great defensive strength.

21. The modern blockade is very costly and requires an immense expenditure of fuel; it is, therefore, a mode of naval warfare which can only be undertaken by moderately wealthy nations endowed with strong resources.

22. The system of crippling the enemy's active forces still awaits confirmation by modern war; after a mutual consideration of the circumstances for and against this method, we believe that steam fleets have the same blockading capacity as is possessed by sailing fleets.

It would be difficult to utter more definite and distinct views upon a method which has not yet undergone experimental confirmation through war. The recent Spanish–American war was conducted as a cruising (see note to 18) and blockading war, it may, therefore, be predicted that the crippling of the enemy's active forces will, in future, also continue to be a most effective kind of warfare.

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* *Kreuzerkrieg* corresponds to the "course de guerre" of the French, called *commerce destroying* by Mahan.

C. THE DESTRUCTION IN BATTLE.

Public opinion generally regards this kind of battle as the only really decisive one, and as that which is understood by the problem of war. In Italy, it is to be added, public opinion does not recognize any other kind.

In spite of this popular wisdom, we believe that history does not support extensively this dogma of the national consciousness, whereas it clearly shows that this kind of naval warfare is seldom decisive and frequently yields indecisive results.

The dissimilarity of the immediate consequences of land and sea battles determines a great difference in the conduct, efficiency and definite accomplishment, which, eluding the superficial observer, becomes manifest, however, by rigid investigation.

We do not propose, certainly, to sift this dissimilarity to the bottom, but restrict ourselves, rather, to the fixing of the source whence springs the false criticism of warlike undertakings at sea, measured by those conducted on land, and to the indication of the difficulty of adducing the guiding principles of a system of warfare as complex, intricate and singular as is the destruction of the enemy in battle.

Owing to this diversity from the homogeneous system of land war and to the instability of government, we restrict ourselves, in deducing, with hesitation, the following abridged principles, to those only, which seem sufficiently supported by history :

1. The method of war which aims at the immediate destruction of the enemy's fleet is the most prevalent one and, from the mariner's standpoint, is also considered the most decisive.

2. The great dissimilarity in the relations between land and sea wars produces erroneous impressions on their ultimate efficiency.

3. The dissimilarity consists particularly in the inability of the sea-power, as compared with the land-power, to accomplish, as a result of battle, the occupation of the enemy's provision centers.

4. The land-power attains the occupation by its victory, the sea-power only attains by victory, dominion at sea, which is not always followed by the occupation of the enemy's provision centers.

5. Sea-power can only be compared with land-power and be

regarded as really decisive, when the existence of the enemy depends entirely upon its supremacy of the sea.

6. The system of destruction presupposes a greater equilibrium of the active forces and a greater capacity for battle due to naval supremacy, than is possessed by either of the systems previously discussed.

7. Naval victories arising from the entire exclusion of the enemy's fleet from the sea, seldom cause an enduring naval supremacy, if an adequate equality of power exists between the opposing fleets.

8. The maintenance of naval supremacy has been due more to political and administrative preseverance in the production of the fleet than to the direct consequences of naval victories.

9. Victories are indispensable for the production of naval supremacy; they can not, however, guarantee this for long without an occupation of the enemy's territory or a constant offering up of sacrifices, in order to make the supremacy of the sea secure.

10. Owing to the alarming effect of victories, the method of destruction in battle arouses, more than either of the methods previously discussed, that enthusiasm and confidence; which is followed by disorganization and loss of naval supremacy.

11. The maintenance of the acquired supremacy demands, more perhaps than its attainment, a very powerful and capable guidance.

12. The direction of conflicts for the attainment of naval supremacy is more difficult, more variable and more easily unbalanced in the system of destruction than in the systems of occupation and crippling, since it depends in a higher degree on the enemy's leadership and initiative.

13. Inadequate leadership and inability to force the enemy to battle and prevent him from attaining his aim, has repeatedly caused, by the employment of this method, complete inactivity and a renunciation of the aim which was the object of the war.

14. Considerations for the political balance and a disire to spare the fleet have frequently caused this system of naval warfare to terminate unsuccessfully.

15. The employment of this method does not require the preparation of the theater of war, it is, however, adviseable to make it, since preparation supports the attack and secures the defense in case of a counter stroke.

16. A speedy and complete equipment of all the naval active forces and all branches of the service corresponding to the prob-

lem of the fleet offers the best protection from the consequences of this method.

17. The destruction of the enemy's fleet in battle exercises a great moral influence upon nations as upon fleets; it also produces, however, great discouragement, from which arises the necessity of employing it daringly and prudently.

18. There is little real probability that a fleet vanquished in a great battle will persist in the conflict to the last extremity, as is done by land forces, unless means are found, in the preparations of the theater of war, for rapidly restoring to a fighting condition.

19. The application of this method is favored when reasonable hope exists of emerging victorious from the battle and when a defeat does not expose the country to a destructive attack.

20. The nature of modern fleets permits the assumption that this method, assuming that the theater of war has been prepared, will be advantageously applied at the beginning of the war and that in subsequent periods, the crippling of the enemy's active forces will predominate.

These principles are somewhat scanty in comparison with the importance of this method, which had military precedence in the past and will, perhaps, also have it in the future. The difficulties which oppose the production of a study upon this subject are so overhelming that they exclude, for the present, the possibility of accomplishing the design, and though this may not absolve, it yet excuses our inability to produce anything better.

d. THE DESTRUCTION OF COMMERCE.

This kind of conflict has been exercised at all times with varied results. It could not, however, be regarded as a regular system of warfare, for the reason that cruising (see note, page 55) or privateering warfare lacked that military organization which is characteristic of a method of warfare.

It could be regarded as a supplementary kind of warfare which may be useful in various ways, but not sufficiently to cause the conclusive determination of war.

Modern conditions of fleets and of the international position permit the assumption that, through organization, this kind of warfare will advance, in time to come, to a method of warfare. We consider it advisable, therefore, to put it on the same plane with the older methods and to investigate the principles which govern its application.

Historical and technical researches permit the expression, with sufficient confidence in their vitality, of the following leading principles:

1. The destruction of commerce causes the exhaustion of the enemy nation, by threatening the commercial relations upon which the existence of the enemy rests.

2. If this object, owing to the condition of the fleets, can not be attained, cruising warfare (see note, page 55) can not be regarded as a decisive kind of conflict.

3. The conditions at the time of galley fleets should have been suited to commerce destroying, yet they prevented the latter from becoming decisive owing to the ease with which it should be opposed.

4. Similarly, privateering made its appearance at the time of sailing fleets except that it was not resultless.

5. The new conditions of modern fleets and the importance which commerce acquires for the vitality of a nation, permit the assumption that commerce destroying may become decisive and be raised thereby to the dignity of a system of warfare.

6. The military organization of privateering is indispensable in order to make it a decisive mode of action and demands open interference by the state.

7. Interference by the state presupposes the preparation of the active forces and theater of operations so as to harmonize with the system, since without such preparation, cruising warfare (see note, page 55) will ever remain a supplementary and subordinate mode of action.

8. The efficiency of privateering depends upon the damaging capacity, the vigilance of the enemy and upon the possibility of injuring the enemy's permanent communications, in short, upon the character of the naval active forces and the defensive means of the theater of war.

9. Independence, speed, small exposed surface, artillery attack at great distances and ramming, and torpedoes at short distances, are the chief properties of the flotilla for cruising warfare (see note, page 55).

10. Good points of support, security of supply of fuel and equipage, facility of disembarkation, good methods of signalling, reconnoitering, and mobilization and other features of a similar nature, are the defensive means for the efficient accomplishment of cruising warfare (see note, page 55).

11. The destruction of commerce may be effected by defensive squadrons, flying divisions and single ships having adequate reserves at the depot of the active forces.

12. The exercise of privateering by single ships, as was formerly conducted, is of no benefit to the state and though it may

gratify private speculation and delude national vanity, it can not form a system of warfare.

13. The destruction of commerce by flying divisions or even squadrons, as prosecuted by England in the time of Elisabeth and Cromwell, may produce good results, when that power which indulges privateering has few foreign interests while that assailed has a strongly developed commerce.

14. In order that cruising warfare (see note, page 55) may be decisive, it must be supported by the naval active force, whose chief problem should be, not the accomplishment of one of the three methods of naval warfare, but the protection of the operations of the cruisers.

15. Cruising warfare (see note, page 55) does not protect the nation exercising it from the consequences of attack by the enemy; it should not, therefore, be adopted as a system of warfare by those states which are vulnerable from the sea.

16. The nations which may consider themselves invulnerable from and upon the sea may engage in cruising warfare (see note, page 55) with advantage; in such a case, if the latter be well prepared, it may become a decisive system of warfare.

17. The circumstances which make it a decisive system of warfare are rather complex and difficult to balance against each other; they do not preclude, however, the possibility that cruising warfare (see note, page 55) in future may be regarded by many nations as a sufficiently decisive system of warfare.

18. The operations of privateers were generally exaggerated so that public opinion is inclined to defend the adoption of cruising warfare (see note, page 55). The wisdom of the state and the science of war must, therefore, develop in the national consciousness a sense of the reality and restrain the imagination, which produces mournful tendencies.

19. Land blockade may be regarded as a kind of conflict which will effect the destruction of the commerce of the enemy.

20. Military science and history likewise condemn this method, which can only be effective when strengthened by an active cooperation of privateers.

21. The present condition of the world's commerce and the European situation preclude the possibility of a political coalition which should aim at decreeing a continental blockade in a universal war.

22. The island nations whose war and commercial fleets preponderate in the situation of the world, are incapable of being

seriously threatened by either a cruising warfare (see note, page 55) or continental blocakade.

These rather incomplete principles permit the conclusion that the destruction of commerce is not yet an actual system of warfare, though it may become such, that no single nation is prepared for its successful exercise and that it will probably remain an auxiliary of naval warfare, as it was in the past.

These four series of principles concerning the four kinds of naval warfare, complete the study of the dynamics of sea-power and conclude the problem which we have set ourselves.

CONCLUSION.

The scientific investigation developed above is assuredly incomplete and imperfect. We trust, nevertheless, that it will enable us to make a close estimate of the potentiality of a nation at sea and will permit the determination of the ways and means of expansion.

The views generally entertained upon military, as upon economical power resources of nations at sea, are almost always so erroneous, so contradictory and so divergent, that every investigation, however incomplete, ought to be of considerable use in educating and guiding public opinion.

The present situation is so pregnant with unsettled questions, so agitated by expansive and colonial efforts, that an exact estimate of the single and combined forces of the state is indispensable in order to avoid a hasty proceeding likely to result in confusion and misfortune.

The first part of our scientific investigation permits an approximate estimation of the expansive capacity of a state, provided the situation is known with sufficient accuracy. The second part assists in deciding on the manner, degree of preparation and decisive methods, which must be followed in order to attain the aim of the expansive motion.

The maxims which we have adduced are considered so scientific and learned, that they present, perhaps, an opportunity for numerous and indefinite interpretations by those who possess but a superficial knowledge of scientific investigations instead of that general historical and military education which is indispensable for the forming of a rational and balanced opinion.

Although we believe that the principles adduced, particularly those relating to politics and economics, may be inaccurately interpreted and subjected to a more or less penetrating review and criticim, we yet hope that the discussion of the pros and cons which may arise will prove highly beneficial to science.

However the present or future fate of our investigation may turn out, we are consoled by the hope that the work which we have produced will not be wholly useless to marine and science.

(Translated by Frank E. Harris, 1st Lieutenant, 3rd Artillery).

EXPERIMENTS IN ILLUSTRATION OF THE TOP-MOTION OF ROTATING OBLONG PROJECTILES.

By Albert Edler v. Obermayer,
Colonel, Austro-Hungarian Army.

Reprinted from *Mettheilungen über Gegenstände des Artillerie und Genie-Wesens.*

The experiments which Neesen* undertook, for the purpose of recording the motion of rotation of oblong projectiles on photographic plates placed within them, have awakened renewed interest in this problem.

Professor Dr. Karl Cranz has recently published in Schlomlich's *Journal of Mathematics and Physics*, a memoir entitled "Theoretical and Experimental Investigations on the Top-motion of Rotating Oblong Projectiles during Flight," which extends the theoretical solution of this problem by taking into consideration an initial angular velocity about a transverse axis, thus approaching much nearer the actual behavior of projectiles than the able theoretical investigations hitherto advanced.

This very noteworthy disquisition, in which are likewise cited the experiments conducted by the author to establish the existence of an initial angular velocity was discussed, and its consequent importance estimated, in these *Mittheilungen*,† by Captain Victor Ritter Niesiolowski-Gawin von Niesiolowice.

I have shown with a Magnus' gyroscope, that the oscillation of projectiles may result from the superimposition of the precessional motion due to the moment of resistance of the air, over the waving motion due to an initial impulse, without disturbing the mean lateral deviation of the projectile points, and, by means of a double-top,‡ have further shown, the connection of this phenomenon with the kinetical properties of rotating projectiles. Prior to making these experiments, I had looked through the usually cited pamphlet of A. v. Rutzky, entitled "Motion and Deviation of Pointed Projectiles" and issued in 1861.

A renewed research of the works of the late Major General A. v. Rutzky, led me to a volume of his artillery studies entitled

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* Archive for Artillery and Engineer officers of the German Imperial Army: "A method of photographically registering the oscillation of projectiles." Volume 96, page 68; volume 99, page 481; volume 101, page 253.

† Year 1899, part 5, page 429.

‡ Organ of the scientific military societies, 1899: "On the Phenomena attending the Motion of Oblong Projectiles in the atmosphere."

"Theory and Practice of Projectile and Fuze Construction," 1871. On page 167 of this work are found statements concerning the rotary motion of oblong projectiles, in which special emphasis is laid on the fact that the rear of the projectile on leaving the bore will be thrust upward. Rutzky attributes this to the current of the powder gases, to the outward rush of the unconsumed powder grains and to the oscillation or motion of the gun.

On page 171 of the work mentioned, Rutzky explicitly alludes to the fact, that since the pressure of the powder gases or the motion of the gun thrusts the rear of the projectile upwards, the point of the projectile, at the first instant of the latter's motion, ought to deviate somewhat to the left out of the plane of fire and consequently the projectile ought to deviate initially, somewhat upwards and to the left of this plane. In this connection, he cites experiments by which projectiles M. 1863, penetrated a thin target standing close to the muzzle, somewhat above and to the left of the point in which the line of sight pierced the plane of the target.

The influence of the powder gases upon the projectile after the latter has left the bore of the gun, is likewise quite probable from the experiments with the Photochronograph of Dr. A. Cushing Crehore and Owen Squire* which has shown an increase in the velocity of the projectile beyond the muzzle of the gun.

The experiments published by Captain Jansen,† a retired Prussian officer, on non-rotating arrow shaped projectiles, indicate the probability that the vibrations of the bore contribute towards thrusting the rear of the projectile upwards.

These experiments consisted in firing wooden projectiles with pointed heads of cast lead, through several paper targets set up one behind the other; the piece being laid normally, an investigation of the apertures, which were 200 mm long, led to the conclusion that the rear of the projectile was thrust upwards on leaving the bore, and that this caused it to execute, during flight, an up and down oscillating motion which was accentuated by the resistance of the air.

When the piece was rotated 180 degrees about its axis and fastened in that position, the rear of the projectile was thrust downwards.

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* Archive for Artillery and Engineer officers of the German Imperial Army. Vol. 102, p 481. *Journal of the U. S. Artillery*, 1895.

† Archive for Artillery and Engineer officers of the German Imperial Army. Vol. 97, pp. 424 and 497.

This oscillating motion of arrow shaped projectiles in the vertical plane, is transformed, in rotating projectiles, into oscillations about the center of gravity, which will be designated as Poinsot motion; this motion will represent the oscillation of these projectiles and will appear independent of the resistance of the air.

Rutzky defines (page 174) the oscillation of rotating oblong projectiles, which are quite perceptible in pointed shells fired with low initial velocities, in the same manner as the Poinsot motion or regular precession will be defined later on. On page 192 he says, "The points of projectiles, in consequence of their oscillation about the trajectories of the projectile, will describe a second helix with many turns." Over this oscillation is also superimposed, according to Rutzky, the deviation of the projectile point to the right, caused by the moment of resistance of the air; this follows directly from his observations.

The deductions of Rutzky quoted above, which characterize, as far as the observation permits, the motion of oblong projectiles very strikingly, seem partly to have fallen into oblivion and partly to have found little esteem. In all the older theoretical investigations of the motion of rotating oblong projectiles conducted by Cranz, Haupt, Mayewski, Oekingshaus, de Sparre, v. Wuich, and Zabudski, the moment of resistance of the air was always, it is true, regarded as the cause of the deviation of oblong projectiles, but it was always taken for granted, also, that the projectile left the bore rotating strictly about its axis of figure, i. e., that it simply had an angular velocity about this axis. In these investigations, the motion of the projectile about the center of gravity caused by the moment of resistance of the air, was usually designated as the motion of oscillation.

In the second treatise of Cranz, mentioned above, on the motion of rotating oblong projectiles, the completion of the theory already noted is undertaken and the oscillation designated as Poinsot motion. Cranz arrived at this result through new experiments and quite independently of Rutzky.

To aid in the comprehension of the motion of rotating oblong projectiles, I had a great quantity of apparatus constructed for the physical cabinet of the Austro-Hungarian Technical Military Academy at Vienna, which has also excited some interest elsewhere.

I believe it my duty here to publish some of the apparatus with which the experiments were made, as also the conclusions already indicated. In the theoretical qualitative expositions, I will avail myself, for the most part, of the methods of conception and notation employed by Klein and Sommerfeld in their excellent monograph entitled "On the Theory of Tops," as I am of the opinion that this notation will prove most effective.

VARIOUS CAUSES OF DEVIATION OF ROTATING OBLONG PROJECTILES.

Scarcely another doubt ought to exist, now-a-days, that the principal cause of deviation of rotating oblong projectiles arises from the action of the moment of resistance of the air about a transverse axis of the projectile, whereby the point of the projectile is forced out of the plane of the trajectory, thus subjecting one of its sides to a greater resistance of the air. Other causes are not, however, barred from exercising an influence, as, for example, those cited in the "Compendium of Theoretical External Ballistics" by Dr. Karl Cranz

To the latter belongs the Poisson effect, i. e., the friction of the air on the surface of the projectile and the internal friction. The deviation of spherical projectiles could not be explained by means of these causes because of their very slight effect ; the same may, therefore, be likewise assumed to be true in the case of rotating oblong projectiles. It should be observed here, that the internal resistance of the air is almost wholly independent of its density. The denser air on the side of the projectile acted on by the resistance reduces the moment of momentum per unit of area, per unit of time, quite as much as the less dense air on the opposite side.

The effect of the impulse in a tangential direction due to the form, (guide studs, channels in the rifling bands, etc.) of the projectiles, is, at most, only a moment which diminishes the rotational velocity of the projectile, and scarcely ever a resultant acting at the center of gravity of the projectile,—a point to which all tangential forces must be referred—and does not produce, therefore, a perceptible deviating force. The presence of such a force would undoubtedly produce a sensible deviation of the projectile similar to that which has been observed. A published computation made on this subject, by failing to take into consideration the necessity for referring the tangential forces to the center of gravity, shows a result in seeming harmony with the observations.

The air condensation on that side of the projectile where the air rotating with it is moved towards the advancing air is designated as the Magnus effect. This air condensation is particularly noticed in the deviation of spherical projectiles; if may, however, also come into prominence in the descending branch of the trajectory of rotating oblcng projectiles moving with points turned upwards. The Magnus effect will diminish the deviation due to rotation.

Deviations to the left have been observed in pointed shells having a right handed rotation. Thus, in experiments made in 1863* with a nine inch (24 cm) rifled mortar, a mean deviation to the left of nine paces was observed under the following conditions:

Number of grooves, 12; twist of rifling, 8½ degrees; weight of charge, 1 lb. (0.56 kg); projectile, pointed shell weighing 139 lbs. (77.8 kg); elevation, 75 degrees; mean range, 275 paces; time of flight 15 to 16 seconds. The axes of the projectiles on striking were vertical.

With the same mortar, a mean deviation to the left of 56 paces was observed under the following conditions:—

Weight of charge, 3 lbs.; elevation, 60 degrees; range, 1900 to 2000 paces; time of flight, about 29 seconds.

The projectiles seem to have struck with their axes in a horizontal position.

With the same mortar, in an experiment made in 1864 under the following conditions, viz:—

Weight of charge, 4½ lbs.; elevation, 60 degrees; and mean range 2330 paces, a lateral deviation to the left of 156 paces was observed.

The experiments with the 8 inch B. L. M., conducted in 1869 and 1870 on the Steinfelder Haide at Viener-Neustadt and reported on by A. Jellinek,† showed an analagous behavior of pointed shell. The twist of this mortar was 3°. The ranges attained by the pointed shell, which were two calibers in length, fired with charges of 4, 6, and 8 lbs. were 1073, 1633 and 2223 paces respectively, giving lateral deviations to the left of 33, 57 and 77 paces respectively. The axes of the projectiles remained parallel to their initial positions both during flight and at striking. The slow flight of the 8″ pointed shells obtained by employing very small powder charges (1 lb.) permitted the oscillations of the projectile points and their gradual turning towards the right to be clearly observed. With an elevation of 60° the projectiles fell at a distance of 300 paces, and, striking the ground point foremost and slightly inclined towards it, tumbled backwards towards the mortar.

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* Communications on the subjects of artillery and war sciences, 1866, pp. 366–368.

† Communications on the subjects of artillery and engineer affairs, 1870, pp, 421 to 424.

In a second experiment* of the same kind, the point of the shell at first turned slightly to the left and then turned to the right.

Rutzky explains that this deviation of pointed shell is due to the fact that the moment of resistance of the air tends to turn the base of the projectile upwards, thereby causing the point of the projectile to turn towards the left. Similar deviations to the left resulted from this cause also, in the Austrian rotation rockets, which, having a right handed rotation, deviated from this cause towards the left, because the moment of resistance of the air tended to turn the rear of the rocket upwards, or, as generally understood, tended to diminish the angle between the axis of the projectile and the tangent to the trajectory.

Since these experiments indicate that pointed shell move nearly perpendicular to the tangent to the trajectory, all the conditions for the introduction of the Magnus effect appear to be present, and may exert here a considerable influence, so that the observed deviation to the left is the product of two causes acting in the same direction.

GYROSCOPE TO ILLUSTRATE THE BEHAVIOR OF ROTATING OBLONG PROJECTILES.

Although the knowledge of the influence of the moment of resistance of the air on the deviation of projectiles may have already been perceived by Poisson, the conception of its value was greatly promoted by the expiriments which Magnus† made.

Magnus constructed a gyroscope, modelled after Bohnenberger's apparatus, in which a projectile model (Fig. 1) could be set into rotation. The axis of the model ends in points which rest in the conically bored ends of the screws $A_1 A'_1$, screwed into the ring R_1 and secured to it by screw nuts. The screws $A_1 A'_1$ permit the accurate adjustment of the center of gravity in the direction $A A'_1$.

The ring R_1 is set into a second ring by means of the screw ends $A_2 A'_2$ which determine an axis perpendicular to $A_1 A_1$. This second ring is similarly set into a fixed ring and has a motion about a vertical axis. All axes intersect in a point which is the common center of gravity of the system.

Simultaneously with the construction of the above described apparatus, Magnus also constructed another with which he established the previously designated Magnus effect, which is defined as—the air condensation on that side of a rotating cylinder, where the air rotating with it is moved against the advancing air current.

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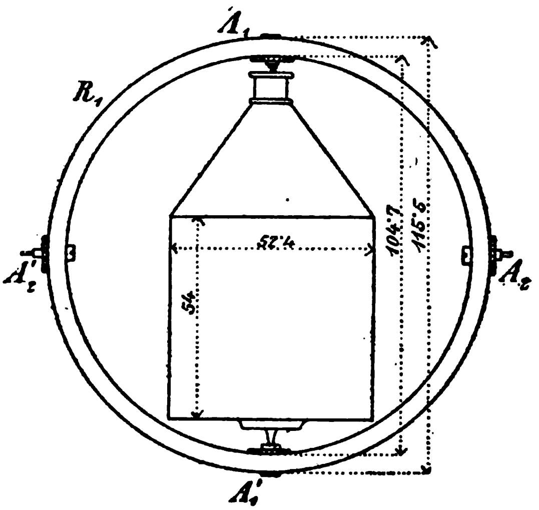
* Rutzky, "Theory and Practice of Projectile and Fuze Construction," p. 181.

† On the deviation of Projectiles and on a Remarkable Phenomenon of Rotating Bodies, by G. Magnus. Poggendorff's Annals, vol. 88, p. 1, 1853.

Fig. 1.

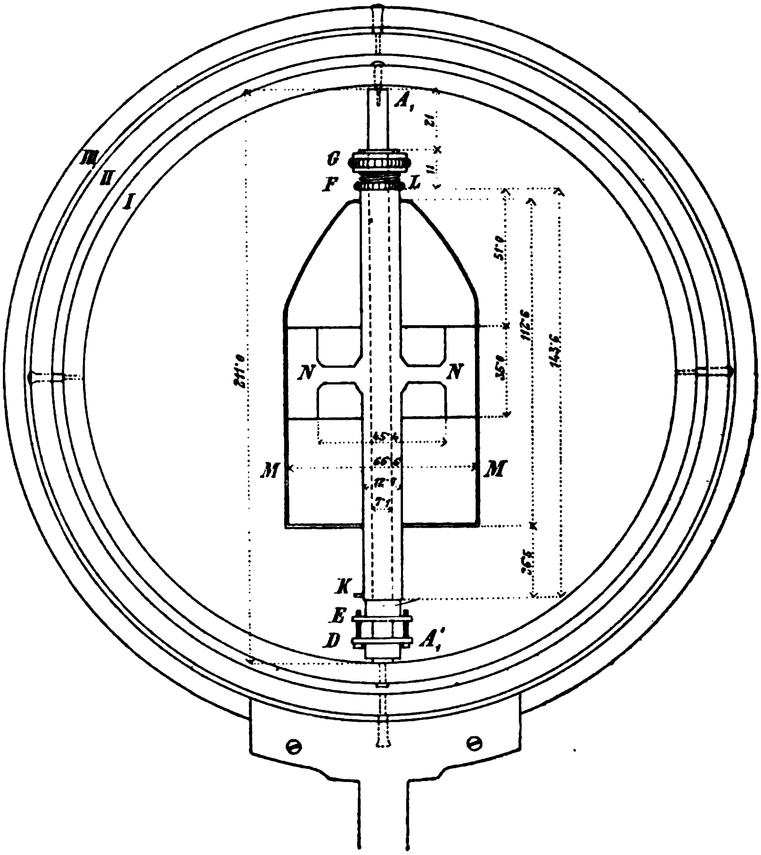


Several copies of the complete series of apparatus seem to have been made in his time. One such series was bought in the fifties for the Physical Institute of the Vienna University, probably through Ettingshausen. I experimented with this apparatus in 1868 under the instruction of Boltzmann supervised by Stefan.

In 1875 I had a Magnus apparatus constructed for the Austro-Hungarian Technical Military Academy at Vienna, by Friedrich Wilhelm Heidl, the mechanic of the institution; the projectile model in this case was given greater dimensions. As this apparatus has found some extension, and as I was also obliged to deliver a written description of it to the service, I felt that such a description ought to be given in this connection. I mention here also, the other models which were tried from time to time, in the ring frame of the gyroscope. All these models, including the original, are drawn to half size in the plate, and may be constructed in accordance with these drawings.

Figure 2 represents Model I of the physical cabinet of the Austro-Hungarian Technical Military Academy at Vienna, together with the system of rings in which it is mounted.

Fig. 2.



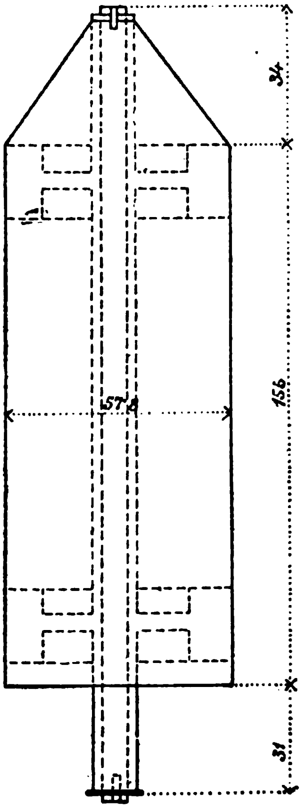
The steel axis $A_1 A'_1$ is 7.1 mm thick and is bored at the ends to receive the axle points. Upon this axis rests a revolving ring N whose axis is hollow; this ring is covered with a brass mantle whose rear end is closed by a brass disc. A pin is secured to the hollow axis at K for the attachment of the draw string which is wound on the free end of this axis.

A small brass sleeve D, firmly attached to one end of the steel axis and connecting, by means of three screw bolts, to a similar movable sleeve E, abutting against the end of the hollow axis, gives a means of accurately adjusting the model upon the axis $A_1 A_1'$.

A mill headed slotted screw *F* abuts against the end *L* of the hollow axis and, receiving the mill headed female screw *G* upon its slotted end, permits the latter to clamp it to the axis $A_1 A_1'$.

The three rings in which this model is mounted were turned out of 6 mm plates of rolled brass and fitted with axes shaped from the ends of screws; their diameters were taken considerably greater than the length of the model in order to allow the air free excess to its surface.

Fig. 3.



If the apparatus is accurately adjusted, the model will remain in equilibrium in every position whether the external ring be placed horizontally or vertically.

Should this not be the case, the trouble is sought in the following manner: insert ring II in ring III, then add ring I and observe in each case whether the rings remain in equilibrium in whatever position placed and whether ring III be vertical or horizontal. Finally insert the model and adjust.

Model II (Fig. 3) of the Physical Cabinet of the Austro-Hungarian Technical Military Academy at Vienna, contains two revolving rings at the greatest possible distance from each other, and shows, in consequence, a noticeably greater moment of inertia about a transverse axis than about the geometrical axis.

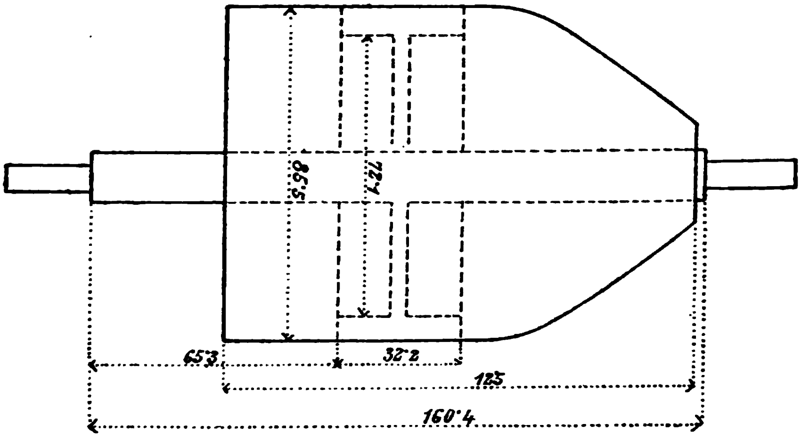


Fig. 4.

Model III (Fig. 4) has a greater diameter than the others and is somewhat shorter; in spite of its small weight, it has a greater moment of inertia about the geometrical axis than the other models, maintains its angular velocity very well, and gives a large moment of resistance of the air, even when but slightly inclined.

[Translated by Captain Frank E. Harris, Artillery Corps.]

(To be continued.)

MAIN AVENUE.

SEACOAST GUN SHOP.

WATERVLIET ARSENAL.

PROFESSIONAL NOTES.

ARTILLERY MATERIAL.

Watervliet Arsenal.

The Watervliet Arsenal was established in 1813 at West Troy, N. Y. (then known as Gibbonsville), as a military establishment, principally for the manufacture, storage, and preservation of field, siege, and seacoast carriages; their implements and equipments; artillery, cavalry, and infantry equipments and accouterments; ammunition for small arms, and cannon and implements, etc., for mechanical maneuvers.

During the civil war, 1861–1865, large substantial buildings were erected east of the canal for additional manufacturing and storage purposes to meet the increased demands of the military service incident to the war, and during that period the Arsenal ranked as the leading and most important one in the country, about 2,000 men and boys being continuously employed in the laboratories and workshops throughout the war.

Field carriages and leather equipment work, principally, of new design, continued to be manufactured at the Arsenal up to the establishment of the Army Gun Factory in 1887, when all that class of work was transferred to the Rock Island Arsenal, Rock Island, Ill., where its manufacture is still continued.

To the first purchase of land in 1813 the limits were extended by other purchases in 1823, 1826, 1828, 1833, 1859, 1861, 1867, and 1869, so that the reservation now embraces about 108 acres of improved land.

The Arsenal is located about 6 miles above Albany, N. Y., within the limits of what is now known as the city of Watervliet, on the west bank of the Hudson River, the name having been changed from West Troy by an act of the State legislature in 1896. It is accessible by water, via Hudson River and Erie and Champlain Canals, and by rail, via New York Central and Hudson River Railroad, Delaware and Hudson Co., Boston and Maine, and Boston and Albany railroads, and connecting lines from all points north, south, east, and west.

Local trolley lines also connect with Albany, Troy, Cohoes. and other towns beyond the points mentioned.

ARMY GUN FACTORY.

The Army Gun Factory was established at the Watervliet Arsenal in 1887, in pursuance of the recommendations of a board of ordnance officers convened by the Secretary of War for the purpose of selecting a suitable site for a gun factory, with a view to concentrating there the available gun machinery on hand in the Department.

One of the large timber storehouses, a two story brick building 392 by 50 feet, was deemed suitable for the purpose of a gun shop. The timber was removed, a shrinkage pit excavated in the rock, and suitable foundations for the machines and floor laid, and the machines and tools taken from other arsenals set up in this building. This work was pushed very rapidly, and the engine and machinery thus installed started for the first time October 18, 1887, and work begun on a number of field guns, also on type seacoast guns.

Preparations were at the same time made for the erection of a large shop to contain heavy machinery in which seacoast guns could be manufactured in large numbers. The north wing with the central section, being about 600 feet long by 130 feet wide, was completed and the machinery started October 18, 1890, and the south wing, being about 400 feet long by 150 feet wide, made the total length of the building about 1,000 feet, and this was completed and put in operation the 18th day of October, 1893. All of the heavy machines, however, were not fully completed and installed before 1895.

The seacoast gun shop is equipped with twenty-five gun lathes, capable of handling guns up to 12 inches in caliber, and four lathes of the necessary capacity for 16-inch guns, and also machines of different kinds and capacity for the preparation of the different parts of the guns and breech mechanisms previous to assembling.

Five heavy traveling cranes, the largest of 150 tons and the three smallest ones of 30 tons capacity each, are running on an overhead structure, for moving the fully and partly assembled guns to and from the different machines and the shrinkage pit.

The central section of this shop contains, besides the steam and electric power plant, a shrinkage pit, with two heating furnaces, for the assembling of the heavy guns. This shrinkage pit is excavated in the solid rock, and is 60 feet deep.

The capacity of the two shops, the first one of which is especially equipped for field and siege guns, and the large shop, equipped exclusively for seacoast guns, is now so large that, with the improved methods and machinery introduced, it taxes to the utmost the capacity for forgings in the rough of two of America's principal steel works, the one at South Bethlehem and the other at Nicetown, Philadelphia, Pa.

The Watervliet Arsenal was selected for the site of the Army Gun Factory because of its deep underlying strata of shale or slate rock, which furnishes (at moderate cost) an absolutely perfect foundation for building, heavy machines, and constructions of all kinds, with ample ground area for expansion of the factory, with its buildings, proof-firing butt, railroad tracks, storage facilities, and facilities for transportation by water or rail for material and supplies as well as for the finished output of the factory.

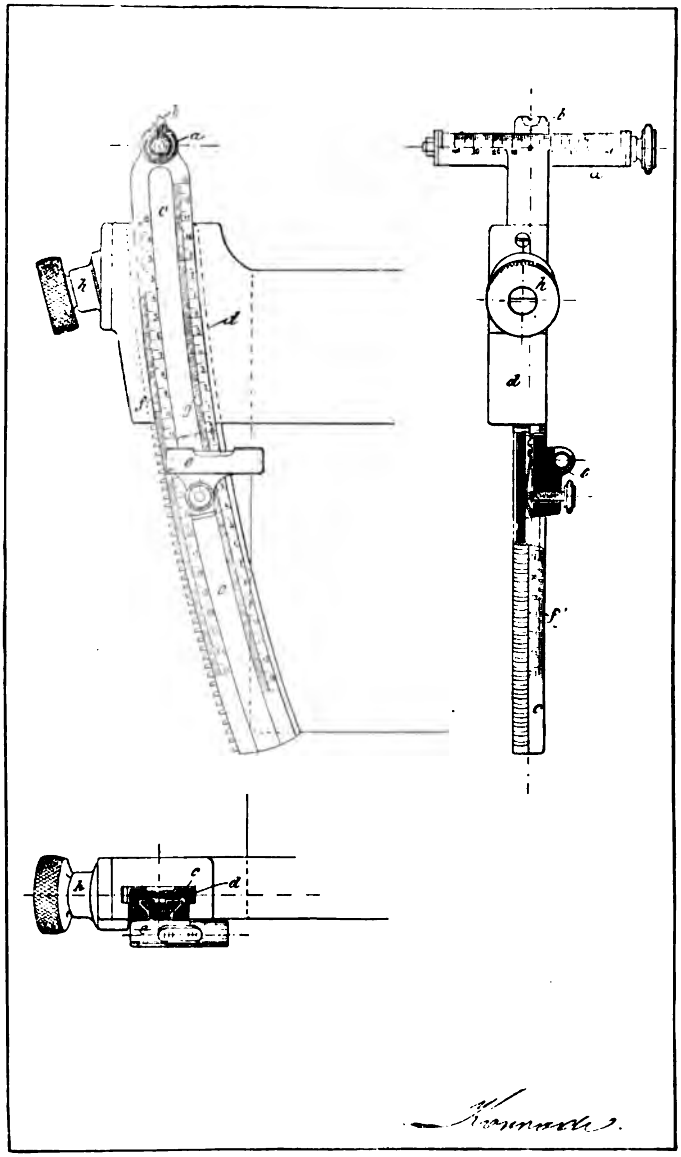
An Alidade Sight for Field Guns.

Rapidity of fire in modern field guns, with restrained recoil, depends on the rapidity with which the operation of laying the gun can be effected. The work of the other cannoneers is always more rapidly done if the laying of the piece is promptly accomplished. Thanks to the adoption of an upper-carriage, turning on a vertical axis, or of some other similar arrangement, the gunner is able to give the exact direction without the aid of assistance (from other cannoneers) and in this way there is already a saving of time. But we will succeed in yet more facilitating the work of the cannoneers and in increasing the rapidity and accuracy of fire by adopting some suitable pointing apparatus and especially by improving the sight.

We consider then, from this point of view, that the use of an alidade sight would constitute an unquestionable improvement. In what follows, therefore, the principles and the detail of construction of a sight of this nature will be given.

The sight-bar of this sight consists of an arc, the curvature of which corresponds to that of a circle described by taking the length of the line of sight between the front and rear sight as as radius, and the point of the front sight as a centre.

This bar slides in a groove which has a corresponding curvature. An alidade, fixed on the sight in such manner that when placed at the zero point, it will be parallel to the axis of the bore, moves through the same angle (as the sight itself does) with reference to the point of the front sight. The result is, accordingly, that this new sight can be used indifferently either as the present sight with a straight bar is, or as a gunner's quadrant. In both cases, the same scale is used for giving the desired elevation. If the sight is used as a gunner's quadrant, one ought to be able to move the alidade independently of the position of the sight, in order to eliminate the angle of site, a requirement that, at the present time is demanded of all quadrants.



We believe that the instrument which we will now describe and which is shown in the drawing, fulfils all these conditions in a simple and rational manner.

The deflection-bar, *a*, the slide of which, *b*, is moved by means of a screw, does not differ from that of ordinary sights. The sight bar, *c*, forms an arc of a mean radius equal to the length of the line of sight, the point of the front sight being the centre. The counter-sunk sight slot, *d*, has a corresponding curvature. On the outside of the sight-bar is a concentric groove in which slides the alidade, *e*. The graduation of the sight is found on the surfaces *f* and *f'*, that for the angle of site, on the surface *g*, both of which are divided into ‰ of the length of the line of comparison.

By moving the alidade along the bar, the angle of site may be determined or eliminated independently of the position of the sight. The alidade is fixed at the desired point by means of a set-screw. The sight bar is moved by a helicoidal gear *h*; for this reason the curved rear surface is toothed. If large movements of the sight happen to be necessary, by turning and pulling the screw, the gear becomes disengaged, and then the sight can be moved by the hand. When the sight is set, the screw cannot by itself be thrown out of gear.

In the different kinds of alidade sights thus far known, the alidade together with its accessories and scale, is constructed at the top of the sight. This increases the weight of the top, and complicates it. Moreover, the small size of the scale for the angle of site renders a vernier necessary or a screw with graduated cylindrical head, in order to read or give the exact elevation. Such arrangements cause mistakes to be easily made and hence diminish the accuracy of the instrument.

By having the alidade in a lateral groove in the rod of the sight, as is done in the construction we are describing, the weight of the instrument is conveniently distributed, and its form is simplified. Besides this, due to the large radius of curvature of this groove as well as of the scale of the angle of site, the divisions of this scale become so large that the alidade can be placed directly at any desired point of the scale, and the reading here as elsewhere on the side of the bar is obtained with complete exactness without making use of any auxiliary means. The service of the instrument is rendered more accurate its use is more simple and more easily understood. Another advantage lies in the fact that the gunner can observe the air-bubble without changing the required position laid down for him in sighting the piece, since the alidade is always placed below.

As to the mode of use of the alidade sight, according to the kind of fire, the following remarks may be pertinent:

In *direct fire*, the gunner, after having set the sight for the elevation ordered, brings his eye to the level of the line of sight, and proceeds to aim the piece as he would with the ordinary sight. The sight always remains on the gun.

In *indirect fire*, the angle of site, which will have been determined in some manner, is first eliminated by setting the alidade. As soon as the direction has been given, the sight is set at the desired point, according to the range, and then by means of the elevating screw of the piece, the bubble is brought between the marks on the glass, thus giving the desired elevation to the gun.

After adopting the alidade sight, it will be expedient to find out if, in firing at fixed targets or at targets that do not appear distinctly to the eye of the gunner, the elevation should not always be given by means of the alidade. In that way, the dispersion in range of the piece itself or of the whole battery would be sensibly diminished without any loss in rapidity of fire. If then the alidade sight is adopted, the setting of the alidade could also serve to eliminate the difference which generally exists between the elevation on one hand and the time of flight of shrapnel on the other. This difference could be added to the angle of sight if it happened to be a positive quantity, and subtracted if it were a negative.

Moreover other experiments of this nature will demonstrate the practical value and varied application of this sight.

Besides this, if the rule were adopted that, before commencing to fire and after having aimed the piece with the elevation ordered, the angle of site should be eliminated—effected automatically by bringing the bubble between the proper marks by setting the alidade—it would be possible, if circumstances rendered it necessary, to proceed to indirect fire by use of the alidade without further ado, for example when the target happened to be momentarily hidden by smoke.

One of the main advantages of this sight lies in the fact that in both direct fire and indirect fire, the same instrument is always used for aiming, and one that also always remains on the piece. The cannoneers as well as the battery commander become very quickly familiar with its use, and that feeling of uncertainty that is inseparable from indirect fire disappears immediately.

It is to be remarked, in addition, that the different operations as regards moving and fixing the sight ought to be accomplished rapidly and exactly, with the view of limiting the time of aiming to what is strictly necessary.

The first condition is that the sight may be set at the proper point without having to take it off and without its being always necessary to clamp and unclamp set-screws at each change of elevation. It has been already indicated by what means this end has been accomplished. Large movements of the sight are made by hand, by disengaging the gear, while small motions and the exact setting at the desired point are made by turning the screw. This screw can neither be turned nor disengaged by the shock of discharge.

The use of the alidade sight in direct fire will not in general present any direct advantages unless the principle is adopted that the elevation is to be given always by means of the alidade. On the other hand, the advantages that result from its use in passing to indirect fire, and in this kind of fire itself, which is now becoming more and more used, are so great that no artillery in the future can do without a sight constructed in the manner here indicated, one which when compared to the sights at present in service, presents no marked complexity.

Berne, October 31, 1898. H. Korrodi,
Captain of Artillery.

[Translated by Andrew Hero, Jr., 1st Lieutenant, 5th Artillery.]

The Care of Guns, Carriages, and Projectiles.

(Continued.)

POLISHING.

A metal is polished when its surface is bright and clean and the eye can detect no scratches upon its surface. Such a surface upon the hard metals can be obtained by hand only after much labor. The metal about a gun cannot therefore be polished in the true sense but it can be made bright and given a brilliant surface.

If we rub the surface of a piece of steeel (a carpenter's chisel for example) longitudinally with a piece of fine emery cloth we will soon obtain a bright surface showing fine scratches running in the direction in which we have rubbed. If now with the same piece of cloth we proceed to rub in a direction at right angles to that first employed the surface will become dull and lose its brilliancy, showing a lack-lustre white. Metal cylinders are turned in a lathe and the cutting tool makes grooves around the cylinder. The cylinder will present a bright sparkling surface in proportion to the fineness of this groove. If we rub across this groove by rubbing the cylinder lengthwise with emery cloth we at once destroy the brilliancy of the surface. Hence we have a *General Rule* that in using abraiding powders upon the bright parts of a gun or gun carriage we must rub with strokes *parallel* with the direction taken by the turning tool or planing tool. This gives the best results in the shortest time.

If a polished surface becomes scratched we must, in order to restore the polish, rub the surface with a powder that will produce a groove about equal to the scratch. When the surface has a uniform appearance we follow the process with a finer powder and so continue till we reach the finest "finishing powder." A deep scratch cannot be obliterated by the use of fine grain powders only.

THE PARTS OF THE GUN IN DETAIL.

The Bore.—No suitable tool has as yet been furnished for scrubbing rust from the bore. An expanding tool carrying a scratch brush is a crying need. Powdered Vienna Lime followed by rotten stone are about the safest materials to use. Local pressure upon the spot to be cleaned can be obtained by sliding wedges in the head of the cleaning rod. The cleaning powder mixed with oil or cosmic is spread upon the surface of a hardwood block whose surface should be rounded to fit the surface of the bore. The bore of a gun should be kept well covered with cosmic but this should not be so thick as to conceal the surface. The cosmic and rosin mixture should not be spread on the bore save when the gun is to be left without attention for some months. To apply plain cosmic to the bore: Saturate a number of silk wipers with cosmic and spread these wipers over the spring bore-sponge. Pass the sponge head, thus prepared, through the bore and repeat the operation till the entire bore presents a uniform glistening surface. Experience seems to indicate that kerosene under a surface of cosmic tends to make the cosmic "crawl" and cease to adhere. Moreover there seems to be an acid reaction in the use of kerosene by which metal quickly oxidizes after being rubbed with kerosene. Before applying cosmic anywhere care should be taken first to remove all kerosene. This may be effected with benzine or turpentine.

The Bore must be protected from the passage through it of moist or salt air. It must therefore be closed at either end. The present tompion is not entirely satisfactory as the canvas hood mars the surface of the gun and the buckles are liable to freeze tight in winter storms.

The Chamber. This may be reached by hand. Rust can be removed by means of the scratch brush and surface polished with Vienna Lime.

Breech Plug.—Emery should not be used upon the threads. Grady's "Scouree" or Vienna Lime is excellent. Heavy braided sash cord or a 12-inch piece of small canvas hose with a stick through it are very excellent means of applying the polishing materials to the threads. The exterior and flat surfaces of the plug may be cleaned with fine ("flour") emery and oil applied with a block of hardwood and polished with Vienna Lime. Handles may be burnished or polished and then covered with the oil and turpentine "Rust Preventer" already referred to. The recess of the breech plug is difficult to clean. Make a lead casting that will just fit this cavity. To do this remove the mushroom head and plug the spindle hole with an oiled cork. Fill the recess, previously lightly oiled, with plaster of Paris and remove when dry. An exact counterpart of the recess is thus obtained From this make a mold of plaster of Paris or a mixture of sand and plaster of Paris. When this mold is *perfectly dry* run in lead (preferably type metal) and before the metal sets insert a piece of square iron or a broken brace-bit. We now have a metal counterpart of the recess which can be revolved by means of a carpenter's brace. Charge the surface evenly with one of the polishing pastes given below or with a mixture of fine emery and cosmic, insert in the recess and with the aid of a carpenter's brace revolve it in the recess with moderate pressure. Of course the mushroom head is previously removed.

The canvas breech cover condenses moisture and sweats the breech. In ordinary weather it is better to dispense with its use.

The Console may be polished with "Scouree," Putz pomade, or "Solarine," applied with a woolen rag or chamois skin.

Breech Plate:—Scrub with No. 00 emery and follow with emery flour and finish with Vienna Lime. The rubbing strokes should all be in the same direction. Emery in the form of bricks is most convenient but emery cloth attached to smooth blocks will serve. *It should be noted* that powders of different kinds or of different degrees of fineness should never be applied by the same cloths, blocks, or sticks. Work would be ruined by so doing.

Screw Heads:—Screws should be withdrawn and their heads polished on hard wood blocks, with polishing powder.

Nuts:—Are polished with flat or square sticks. If they can properly be removed a stick is run through them and they can be rubbed on a hard wood block

The Vent:—Owing to vent having a choked bore it cannot be satisfactorily cleaned with a rod. Proceed as follows:—Remove the mushroom head and rest the bore end of the vent upon a flat piece of cork. (A slice from a medium large bottle stopper will serve.) Remove the surplus grease as far as possible and then fill the vent with a strong solution of lye. Stir this about with the priming wire and allow it to act for some time. Then lift the mushroom head from the cork and allow the lye to drain out. Repeat the operation if necessary, and then flow clean water through the vent. If rust is found in the vent fill it with a saturated solution of potassium cyanide and allow it to act for several hours After thorough washing again place the vent upon the cork and fill the vent with alcohol. Let the alcohol act a minute and then drain off. Again place upon cork and fill vent with the oil and turpentine "Rust Preventer." Raise the mushroom head upon blocks so as to allow the vent to drain thoroughly. In about an hour replace the mushroom head in the block and keep the vent always closed with an old primer previously filled with melted lead. A vent so treated should remain clean and in serviceable condition till a primer is used when the above process will have to be repeated, wholly or in part.

The Piston Rods: -If there is rust on the rods remove it with scratch brush. Then apply abraiding powders beginning with the finest emery that will serve and follow with finer emery ending with Vienna Lime or rotten-stone. Apply the powders in a paste form, (such as one of the recipes given further on), upon the middle of a long strip of canvas. Pass the end of this belt over the cylinder and with an end in either hand saw across the cylinder moving gradually in the direction of the axis. A piece of emery cloth or crocus cloth may be used under such a belt. After the "finish" polish is applied place a burnishing chain under a clean belt and rub till a brilliant surface is obtained. The effect of the burnishing chain is very pleasing.

The Cross Head Guides are cleaned with rags wrapped about blocks or sticks, and lubricated with cosmic.

The Ratchet Teeth are cleaned with emery cloth and covered with several coats of "Rust Preventer" applied with the finger and well rubbed in.

Gears are cleaned with sticks using such abraidients as may be proper for the metal of which the gears are composed. These are then oiled with cosmic, or if small, Ohlmsted's preparation may be used—see further on.

Sight Standard:—As this projects above the parapet it would be a conspicuous mark if bright. It should have a bronzing lacquer such as instrument makers use or in lieu of something better cover a with a mixture of graphite and oil. Take care that the sight notches are kept clean. The latter must not be scraped in any way as that would derange the sight.

Gun Weights:—The handles of the movable weights are peculiarly liable to rapid oxidation. They lie in recesses that are constantly filled with rain. These handles should be cleaned and then covered with a coating of Red Lead. Ordinary paint is better than nothing but must be frequently renewed.

WOODEN HOODS.

To protect the piston rods of disappearing carriages water-tight wooden covers are very useful and where there is much drifting sand such covers are absolutely necessary. They should cover the length of the piston rods and extend below the chassis rails. A box to cover the tops of the cross head guides should also be provided.

HAND BELLOWS.

After a rain water settles in beads and pools along the chassis rails and other places. Ordinarily much time is consumed in wiping off the water, a process which also removes the protecting cosmic which has to be removed at once. A moulder's hand bellow's (measuring about 12 inches across) is a most useful tool. Water may be blown off the oiled surfaces, without disturbing the latter, by the aid of bellows, and corners, otherwise difficult to get at, may be quickly cleaned of water, sand or loose dirt.

RUST ON POLISHED STEEL.

Cyanide of Potash is most excellent for removing rust and should be made much use of. Instruments of polished steel may be cleaned as follows:—First soak, if possible, in a solution of cyanide of potassium in the proportion of one (1) ounce of cyanide to four (4) ounces of water. Allow this to act till all loose rust is removed and then polish with

CYANIDE SOAP.

Potassium cyanide.
Precipitated chalk.
White Castile soap.

Make a saturated solution of the cyanide and add chalk sufficient to make a creamy paste. Add the soap cut in fine shavings and thoroughly incorporate in a mortar. When the mixture is stiff cease to add soap. It may be well to state that Potassium Cyanide is a violent poison.

RUST ON IRON.

Iron may be quickly and easily cleaned by dipping in, or washing with

Nitric acid	one (1) part,
Muriatic acid	one (1) part,
Water	twelve (12) parts.

After using wash with clean water.

ABRADING SUBSTANCES.

For polishing metals various abrading substances are used. Their hardness and fineness vary and the use to which they are put varies with the metal to be polished and the degree of polish desired. Hard metals, like tempered steel, require a hard and sharp polishing material, while brass and other soft metals respond to the softer and finer powders. The various abrading substances are often combined with each other in varying proportions, sometimes in the form of blocks and sometimes in pastes or with liquids that either perform some active service upon the metal to be polished or serve as a bond or medium to keep the powders together and to retain them upon the metal under operation.

Emery:—This substance is to be had in granular form of every degree of fineness from a fine powder or "flour" to that of a medium coarse bird-shot.

Emery Cloth consists of cloth covered on one side with emery. It is graded according to the fineness of the emery coating and is usually to be found in the markets in all grades from FF to No. 3, the latter being the coarsest. Except for the very roughest work No. 00 is the coarsest that should be used on the bright steel or iron metal of a gun. It is too coarse for brass.

Emery Paper consists of a strong paper with an emery surface used ordinarily from 00 ta No. 3.

Emery Stones or "scrub stones" are blocks of compressed emery and are used for scouring or brightening large surfaces. They have all grades of fineness.

Emery Files are compressed emery in the shape of files,—round, square or triangular.

Emery paper is better than emery cloth for very fine polishing in bench or lathe work but about a gun and gun-carriage the cloth is more convenient. For use in obtaining a very fine surface old (used) emery cloth is better than new (unused). Emery cloth should not be discarded till it is actually worn out. There is a strong tendency on the part of the members of the gun detachment to use fresh emery cloth whenever they can get it. They like to feel the new cloth bite the metal.

Carborundum is similar to emery in application. It is said to be harder and sharper than emery.

Chromate of Iron is used for giving a "mirror polish" to tempered steel. It is very expensive ($4.35 a pound) but a little goes a long way if properly used. *To use*:—Spread a very little of the powder upon a block of hard wood or stick suited to the surface in hand and rub hard till polish is secured.

Diamantine for polishing small instruments of tempered steel. It is used by engravers to give a very brilliant polish to their engravings. It is more expensive even than chromate of iron. Use dry.

Pumice in the form of bricks or powder is used to smooth the surface of paint. It is used with water. (5 cts a lb.)

Rouge (35 to 50 cts a lb.) is used for the soft metals. Nickel rouge is a variety used in finishing brass. (15 to 20 cts a lb.)

Rotten Stone, a very fine powder, used in "finish" polishing steel or brass. (10 cts a lb.)

Tripoli:—Used in polishing brass, (20 cts a lb.), especially when in the form of "Tripoli Composition" or "White Composition" (10 cts a lb.)

Vienna Lime:—Valuable in polishing steel. Should be kept in closed cans or bottles as it deteriorates when exposed to the air.

The efficiency of abrading powders depends upon the uniformity of grain whether the work to be done is coarse or fine. If fine grains and coarse grains are mixed together the fine grains clog the large grains and prevent efficiency in heavy work, while for fine word the coarse grains scratch or destroy the work done by the fine grains. Abrading powders should therefore be elutriated. (See below.)

CLEANING MATERIALS.

To apply the various polishing powders and pastes we make use of cloths, leather, chamois skins, elk skins, blocks and sticks of hardwood, etc. The Ordnance Department supplies silk wipers and cotton waste.

Cotton waste:—This is the waste of cotton mills and is universally used by machinists for wiping purposes. A machinist usually picks it over before using so that the mass in hand shall be spongy and free from lumps. It is excellent for all rough wiping about a gun and gun-carriage. It must be used with discretion about gears as it leaves much lint and will tend to choke small gears. Oily waste is liable to spontansous combustion so it should be kept in tin cans. There are special cans for this purpose made of galvanized iron with self closing lids. These have not yet been supplied. Oil waste should not lie upon the concrete where it will pick up grit and dirt. It should be kept in its own receptacles. Oil waste is constantly dropping into the pits of the gun and mortar mounts. This is a menace to the drains and requires vigilance.

Silk Wipers are used for finish wiping. They do not leave lint like cotton waste. Silk wipers may be cleaned by soaking in a strong solution of borax and then washing in clean fresh water.

Pass Boxes:—Large quantities of old pass-boxes and budge barrels are now being condemned. These make excellent receptacles for cleaning materials. They preserve the materials from dirt, are handy to carry prom place to place and keep the storeroom and emplacement tidy in appearance.

Leather:—Leather straps are very superior for polishing piston rods and cylindrical surfaces. The hair (smooth) side is charged with the polishing powder and the belt is passed over the part to be polished, an end taken in either hand, and by a sawing motion a fine polish may be obtained. Condemned gun slings serve excellentiy.

Canvas:—Canvas of light fine quality torn into long strips ranks next to leather belts in usefulness. Condemned tentage is a source of supply.

Budge Barrels:—Are useful in a dozen different ways for rreceptacles.

Cloths:—The broad cloth of officers' trousers is the finest kind of material to use in finish polishing both in the form of long strips and small pieces. The strips should be torn from the waist band to the bottom seam and in about three- or four-inch widths. Tacked over a smooth block of hardwood an excellent scrubber and polisher for flat surfaces is obtained.

Wood:—Blocks of hardwood, and sticks of the same shaped to fit a particular place, are useful in applying polishing substances. Boxwood is the *ideal* wood for this purpose but it is too expensive. Pieces may be picked up here and there in the shape of a broken carpenter's or draughtsman's rule. Persimmon wood is very similar and is easily obtained in some places. Dog wood is excellent and easily obtained. Beech is also good. The boxes containing box plug tobacco are of beech. The canteen or commissary can supply this in limited quantities. Fuze plugs of old patterns are made of beech and can be made use of.

Burnishing:—This is effected with a piece of hardened polished steel or polished agate. The surface to be burnished must be free from all scratches as burnishing emphasizes scratches. Only just sufficient pressure should be used to obtain the end desired. Too heavy pressure causes "guttering" of the surface. The burnisher should be cleaned upon a crocus buff before using. A little oil is used with burnisher upon steel and water upon brass. A "burnishing pad" is used in some places. This consists of a steel chain mounted upon leather backing. It is particularly useful upon piston rods.

Scratch Brush:—This is a most valuable tool and one that seems little understood. It consists of a brush made of fine steel wires. It will remove rust from a piece of metal without injury to the surface. Metal scales that have become rusty may be cleaned by simply scrubbing them with a scratch brush and this without injury to the divisions of the scale. Rust upon surfaces that have been "bronzed" can be instantly removed by this tool and the surface restored to its former condition.

CAPTAIN HAMILTON ROWAN, ARTILLERY CORPS.
(To be continued.)

Modern Artillery.*

By A. T. DAWSON, late R. N.

(Concluded.)

Land Service Artillery.—I think one of the great lessons of the present war is the importance of accuracy of fire at long range. I am told by eye-witnesses, that on some occasions our forces were subjected to attack at range of over 11,000 yards and with some effect. I do not think it is unreasonable to assume that such experience will again be met with in future European wars. It is, therefore desirable in the construction of field artillery to lay particular stress on the importance of the conditions governing accuracy of fire at these long ranges. In discussing field artillery recently with a great foreign maker, he informed me that his great aim was to construct a field-piece which at 10,000 yards, would be capable of attaining a very quick rate of fire, and, if necessary, of laying all the rounds within a 10-metre square. He further said that the gun he was experimenting with, after recoiling, returned exactly to the same position, and, generally speaking, required only the most minute adjustment to the sight in order to bring it into alignment. I myself see no reason why the greatest possible accuracy should not be obtained. I am not, of course, dealing with the question of the bursting of the shell, but of the actual accuracy of range and direction. I do not propose in any way to endeavor to describe the field guns we are at present using in the Transvaal, as the majority of them were designed many years ago, and are well known to most of you.

There must, of course, be much divergence of opinions as to the general conditions to be met in field artillery, but I think, with our present experience, we must all agree that the most important point to be aimed at is accuracy of fire at long ranges in conjunction with a quick rate of fire with the minimum of weight behind the horses. Such conflicting conditions are difficult to obtain, and the general results must necessarily be some form of compromise. I am myself much inclined to favor, for modern field artillery, a heavy type of shrapnel, for the reason that much greater accuracy is obtained at the long ranges, and such a shell admits of the employment of a high-capacity shrapnel. This has the disadvantage of reducing the number of shells carried, which, however, is not important within a limited number, as it only means the necessity of a proportional increase in the number of ammunition wagons, and if we accept the fact that a three-gun battery of modern quick-firing pattern will do the work of the present service six-gun battery, the extra supply of ammunition wagons will not entail an increase in the number of men and horses for the efficient general working of the modern battery in action.

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* Paper read at the Society of Arts on March 6.

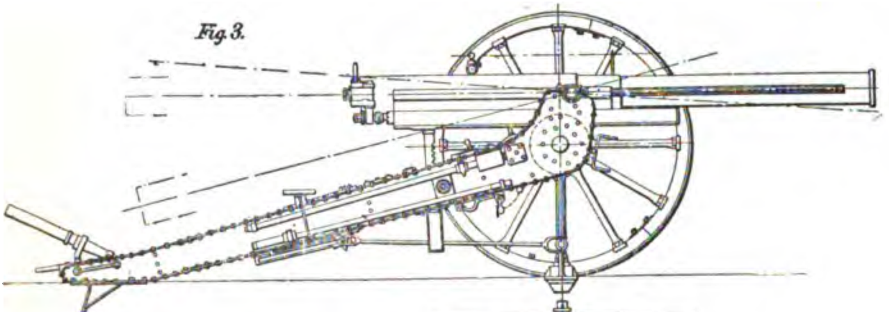
Time Fuses for Shrapnel Fire.—Before dealing with a few general types of modern field guns I would like to point out that, however good the gun may be, it is of the greatest importance that when the shrapnel reaches its billets, it should burst accurately, and for this reason the time fuse made use of with shrapnel cannot be too well constructed, and should be as efficient as possible. The actual cost of the fuse in the field batteries is comparatively small, having regard to the total cost of the equipment, but if these are not efficient, the whole battery is of little value. The greatest attention should thus be paid to the general construction of fuses.

At the present time the best time fuse available is that manufactured by Krupp, of Essen. I have had much experience with these fuses, and have never known one to go wrong. This fuse has such a good name on the Continent that it often happens that countries prefer to purchase ammunition from the German firm of Krupp, rather than from Schneider and other French makers. The small guns used by our troops against the Soudanese were supplied with ammunition fitted with these fuses. and I have heard nothing but good accounts of them. The guns used in the Ashanti operations recently were also supplied with Krupp fuses, and I have been informed that, notwithstanding the serious climatic changes to which they were subjected, not one went wrong. The guns of the American forces used in the Philippines, fire only Krupp fuses ; I understand they are still continuing to procure them. I mention this with special regard, not only to the great importance of fire, but also to the accuracy of shrapnel effect. The particular fuse I refer to can always be kept screwed in the shell, and all that has to be done in setting it is to turn a ring to the required distance by means of an ordinary tommy. Such an arrangement admits of very rapid time setting, which, with modern artillery, is absolutely essential.

Quick-Firing Field Guns.—In regard to the general types of quick-firing field carriages at present utilised, I believe I am right in saying that the Maxim field carriage was the first successfully tried in Europe. This carriage is fairly well known, and has been supplied to a great number of countries; but we in England, perhaps, more generally know it as having been the one selected by the C. I. V.'s for use in the Transvaal. In this arrangement of carriage the gun layer sits on a seat attached to the trail, and the recoil is taken by means of a spade, the gun recoiling axially in a cradle, while the energy is absorbed by two hydraulic cylinders placed on each side. I specially mention this construction of carriage, because, notwithstanding the great number of years which have elapsed since it was introduced, all the most modern carriages of the present day are designed on the same lines.

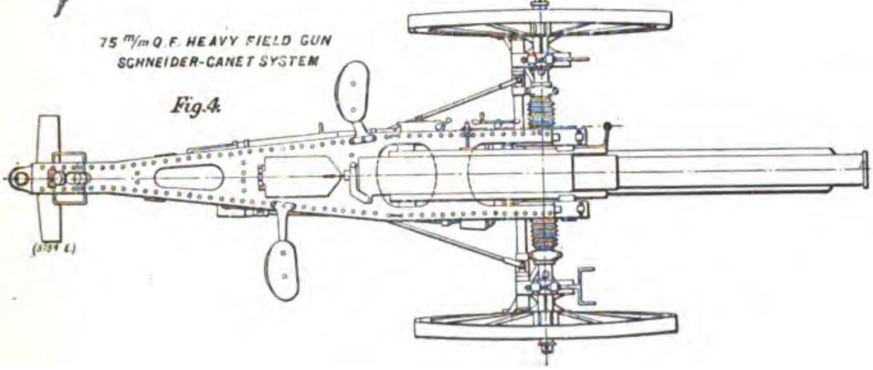
In dealing with the foreign systems of carriages, I would point in the first place to that at present being utilized by the French Army. The French are at the present moment credited with having the most efficient artillery in Europe; it is well known, however, that recently they have changed their pattern, and have now only about 1000 equipments of the latest form in the service. It is believed that they have adopted a heavy form of shrapnel, weighing about 8 kilogrammes, and that the gun has a velocity of some 1700 feet. Notwithstanding this high power, it is capable of easy control so that there is practically no movement in firing, and the gun is, after recoil, returned to the firing position, so that it can be rapidly relaid by the gunner, who always remains seated on the trail. It is said that in practice the French gunners have obtained a rate of fire of over 30 rounds per minute. I need not say that to obtain such a high rate of fire it is necessary to make use of fixed ammunition in which the projectile and metallic cartridge are in one. The gunner who works the mechanism remains during firing on a seat on the opposite side to the gun layer. There is some advantage in the men sitting on the carriage during firing as it increases its weight and keeps it steadier during practice, and the men at the gun have also some protection. The mounting is of the type in which the gun recoils in a cradle, the carriage being fixed rigidly in its position by the spades, one under each wheel, and one at the trail. In order to keep the strain upon the carriage low during fire the gun is able to recoil through a distance of 1 metre. In order to obtain the most careful accuracy in laying, the gun layer is able to train the gun with its

Fig. 3.



75 m/m Q.F. HEAVY FIELD GUN
SCHNEIDER-CANET SYSTEM

Fig. 4.



trail and top carriage complete, relatively to the axle through an arc corresponding to 300 metres at 3000 metres, or 6 degrees. I am not able to show you the actual drawings of the French field gun, but I am able to show several photographs of the equipment generally, and a diagram representing one of the types of Creusot guns, which embody some of the general principles made use of in the French mountings. (Figs. 3 and 4.)

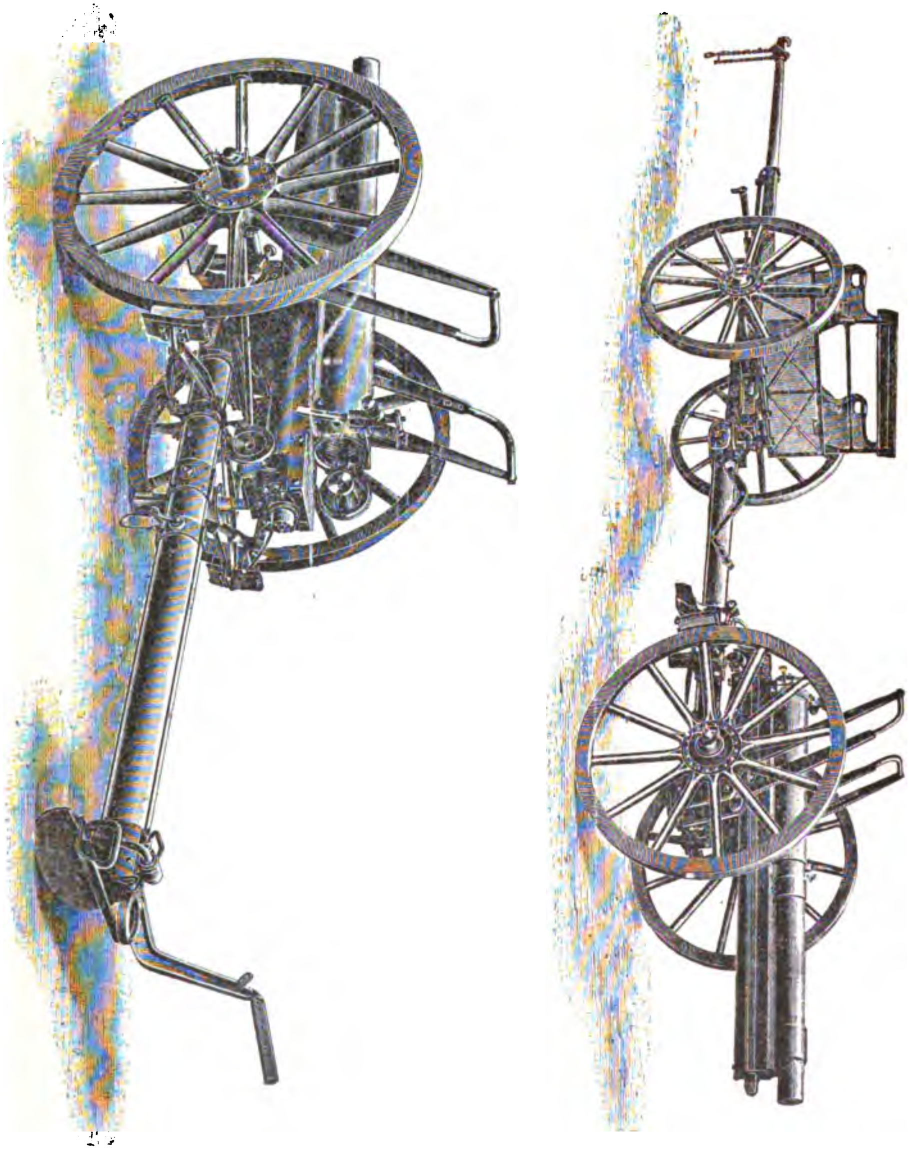
This gun and carriage makes use of priuciples which I am inclined to think will be generally adopted by most countries, as they admit of high power, accuracy of aim, and a quick rate of fire when necessary. I do not wish to give it as my opinion that the details will be by any means followed by other countries, but rather that the general system assists greatly in the relization of the best conditions of a quick-firing field gun.

I will now pass to another typs of French carriage designed by the St. Chamond Company, and which has been tried in connection with our own Horse Artillery, of which I am able to show general representations. I consider this to be a very good type of carriage, enabling general quick-firing conditions to be obtained for moderate weight. The recoil of the carriage is taken by a recoil cylinder fitted under the trail, at the end of which is a spade, the carriage, gun, wheels, etc., recoiling over it. By this means the energy of recoil is absorbed. and after recoil the carriage is brought back to the firing position by means of a spring outside the cylinder. Very good general results have been obtained with this carriage, and the Spanish Government have finally adopted it as being the most suited to the general conditions existing in that country. The gun used in connection with the mounting is one of Vickers-Maxim construction, using fixed ammunition.

The German Government have adopted a much simpler form of mounting than the French, and up to the present have preferred only to have a spade at the end of the trail which can be used or not, as the ground determines. I understand that they have now changed their idea, and are likely in the near future to adopt a mounting so arranged that the gun recoils in the cradle on a fixed carriage.

I would now refer to a carriage of which I understand from the Press a certain number have been introduced into the British service, namely, that manufactured by Messrs. Ehrhardt, of Dusseldorf (Figs. 5 and 6). The system utilized is generally similar to the type I have just described, where the gun recoils in a cradle. One of the features of the carriage is that it has a telescopic trail, and, when firing, the telescopic trail is pulled out so as to have the advantage of the long trail for preventing unsteadiness and jump in the mounting. There are no special features in this mounting to which attention need be specially called, but I would point out that telescopic trails have always been considered objectionable for the reason that the rough usage on active service is liable to strain such a flimsy construction, and when the gun is in action the mere fact of a rifle shot or shrapnel bullet hitting the thin material of which the tubes are constructed will prevent its being pushed in and out. I am given to understand that on many occasions, both in firing and during transport, the axle has shown weakness, which rather renders the discussion of such a system superfluous, for, however clever the general design of a particular mechanism is, if it will not stand the ordinary rough usage on active service it is of no good to the practical gunner. The German Government have had this carriage tried, but have no intention whatever of introducing it.

Mountain Gun.—Under the heading of field artillery I will now briefly refer to a type of mountain gun which has done good service to the Empire—the 75-millimetre mountain gun (Vickers-maxim type). This gun has recently been used with considerable effect in Ashanti with the column operating under the command of Sir James Willcocks, who, I believe, has a high opinion of it, as it never failed to do its work efficiently in this trying climate, notwithstanding the floods, damp, &c., through which it had to go. It is a gun also well known to others who have served in Egypt, having taken part in most of the campaigns in that country. Its great advantage is that it is very



FIGS. 5 AND 6. THE GERMAN GUN CARRIAGE IN USE IN THE BRITISH ARMY (MESSRS. EHRHARDT, DUSSELDORF).

light, and can be taken to pieces very rapidly, and carried in parts either on mules or by native bearers. There is nothing complicated about it; and it is not, therefore liable to get out of order. It is designed on the lines of a modern quick-firing gun and carraige, and consequently its firing effect is very accurate. It fires projectiles of $12\frac{1}{2}$ lb. and 18 lb., and can operate at ranges up to 4500 yards. This gun was used extensively by the Americans in the Philippines, and notwithstanding the very rough usage it was put to, gave the greatest satisfaction to all concerned. I am glad to say it has now been adopted by His Majesty's Government for most of our Colonial operations, and is being used by our forces against the Chinese. It is not a gun of great velocity, but its curved trajectory, using the 18-lb. shell, has a searching effect against entrenchments, &c., when direct fire would be but waste of ammunition.

I have not enough time to devote to the consideration of all the various types of ordnance used in the field, but I cannot help urging that the fewer types employed the better, having regard to the difficulties of transport, and other complications in arrangements inevitable to the movements of a large force. The nature of the types selected for each particular campaign must be dependent on the nature of the territory in which the ordnance is to be used, and owing to the extent of our own Empire and the great variety of countries included, it is necessary for us to keep a large reserve of ordnance of every available type, each equipment being located in the particular country in which it is specially adapted and is to be employed.

Automatic Small Arms.—There is one gun, however, which, like the rifle, is employed by every country of the world—namely, fully automatic rifle-caliber guns. The system almost universally adopted is that at present used by His Majesty's Government—namely, the operation of the mechanism by the recoil of the barrel, which is the distinctive characteristic of the Maxim gun. Other systems are to some extent used, such as the Hotchkiss and Colt, in which the waste gases at the muzzle of the gun are used to operate their mechanisms; and although this arrangement is not generally employed by the Vickers-Maxim Company, it was originally the invention of Sir Hiram Maxim, who has constructed some very perfect weapons on this system. The strain, however, on the material is rather higher, and for this reason the recoiling barrel system is preferred.

Heavy Types of Automatic Guns.—I must now pass to the consideration of some other types of automatic guns, and I would first briefly call your attention to the "Pom-Pom," of which many are in use at present in South Africa. I have heard many criticisms of these guns; some officers have told me that their great advantage is the moral effect they produce, which conclusion I question. Others have assured me that if the projectiles hit anything alive they kill it, and of this I have no doubt.

It should always be remembered that the projectiles are one-fifteenth the weight of the field gun projectile, and therefore their results cannot in the least be compared. To my mind their great use is for operating with artillery and cavalry, for the protection of the flanks of batteries against cavalry attack, for finding the range for working with outposts, and for the protection of bridges, and other important strategic positions. It is by no means necessary to work these guns in the field as field weapons; they can be carried on pack saddles for special operations where field artillery would be impossible and the strategical results would be most important.

Other automatic guns to which some consideration has lately been given, are the 3-pounder, 6-pounder, and 9-pounder guns. To render these guns fully automatic would necessitate certain attrchments which, like all mechanism, would be liable to get out of order, and require a certain amount of skilled attention. But I am strongly of opinion that guns of these calibres should be at least semi-automatic, so that after the gun is fired, the action of recoil may open the breech, throw out the empty case, and put the gun in position ready for receiving another charge. The only operation left for the loading gunner is to push home the cartridge which forces the exterior forward, allowing the mechanism to close itself "ready" for firing. Such a mechanism is highly important in the present day, especially on board ship, where in war attack by torpedo-boats and submarine boats must always be expected, and where but a few seconds is given for repelling the attack. Thus a semi-automatic gun of moderate caliber should make all the difference between rendering such attacks disastrous or futile. The representations on the screen show a 3-pounder fully automatic gun and a semi-automatic 14-pounder of the Vickers-Maxim type now universally adopted by the United States of America. (For illustration, see *Engineering*, vol. lxix., pages 180 and 181.) Such semi-automatic guns are not more complicated than guns having the ordinary form of mechanism, and they have a great advantage. They are as equally applicable for fortress purposes as for ships, and a smaller gun's crew can work them.

Field Howitzers.—Before finally leaving the subject of land service artillery, I would like briefly to refer to the use of howitzers in the field. The special use of these pieces, as most of you know, is for indirect fire where high trajectories are necessary, and where nothing but a large angle of descent of the projectile can prove effective in attack. A large number of such weapons are now in use in the Transvaal, but for general purposes of demonstration I propose to briefly refer to a large 24-centimeter field howitzer used by Austria for the protection of its frontiers. I understand the Austrians have at least seventy of these howitzers in course of manufacture. A good many of them have been already delivered, and form an invaluable part of the main armament of that country. The special feature of this howitzer is the very heavy shell it uses—of 300 lb. weight, containing a heavy bursting charge of high explosive. Its use is really for heavy siege work, but it can be got into position and made ready for firing in some 20 minutes from its arrival at the particular spot where it is to be used. The gun, with its cradle, axle, &c., is carried in one load on a four-wheeled wagon; the lower carriage, bed-plate, &c., is carried on a similar arrangement as a second load. It is intended that this howitzer should be brought up by rail to within a short distance of its point of installation, and then dragged by any suitable haulage system to the entrenchment which would be prepared for it beforehand in the ordinary way. The bed-plate is first staked down, and then the carriage is lowered by screws on to the prepared ground, after which the gun with the trail, &c., is run into position on the carriage by suitably inclined wedges. The energy of recoil is taken by a hydraulic cylinder and the gun run forward into the firing position by means of springs, in the usual way.

—*Engineering*, (London).

BOOK REVIEWS.

Krieggeschichtliche Beispeile des Festungskrieges aus dem deutsch-französischen Kriege von 1870-71. Von Frobenius, Oberstleutnant a. D. Fünftes Heft. Berlin: E. S. Mittler und Sohn. 1901. 3.75 Marks.

This fifth number of this excellent exposition of the battle tactics of land fortifications, as exemplified in the Franco-German war of 1871, adds another to the series by one of the world's recognized authorities on the subject. The preceding number having dealt with the attack by the means available in the field army, the present number takes up the subject and continues it by treating of the work of the siege artillery, particularly in the attacks on Verdun and Toul.

The author lays particular stress on the fact that the method of attack in 1870 must be considerably modified in future wars, indeed, that is the most important lesson to be derived from a careful study of this war.

Our reviews of previous numbers of this series are referred to for the general character of these studies.

It is not too much to say that this series constitutes the best material for the study of this subject known to military literature, and we can heartily recommend it to military students as a clear, graphic, logical and convincing presentation of the attack tactics of land fortifications. J. P. W.

Military Law Made Easy. Major S. T. Banning. Aldershot: Gale and Polden, Ltd. Four Shillings and Six Pence.

This volume is one of the *Military Series*, prepared to assist officers reading for the promotion examination. The author was well equipped for his task, as, he is a Barrister-at-Law, and Instructor in Military Law at the Royal Military College, having had ten years of experince as instructor of law.

It is an excellent catecnism of the subject, systematic, clear and easy for reference, and although written for a special purpose it will also be useful to the general reader or student interested in British Military Law.

J. P. W.

Boxing: The Modern System of Glove Fighting. Captain W. Edgeworth-Johnstone. London: Gale and Polden. Two Shillings and Six Pence.

The Introduction to this work opens with the statement:

"I have been induced to bring this work before the public in the hope that it may lead to our amateurs adopting a more practical form of Boxing, and also that some of our professionals may think it worth their while to study more closely American methods of training and fighting."

The author is an officer of the Royal Irish Regiment, Assistant Inspector of Gymnasia, and heavy-weight amateur champion of England, 1895 and 1896, and therefore well fitted for his task.

He is impressed with the fact that most amateur boxers are really merely sparrers; they become proficient in ducking, dodging and light flippy hitting, but rarely learn to hit quickly, heavily and accurately, which is the true art of boxing.

The book not only gives the various positions and movement in boxing, but also indicates the necessary preliminary courses of training to acquire proficiency. All these are well illustrated by many excellent illustrations. At the end of the volume are some interesting essays on Boxing in the army, American *versus* English Boxers, Physical culture at Public Schools, and a brief notice of professional boxers of our time.

It is altogether a useful little book, healthy in tone, and written by a true lover of sport. J. P. W.

The Army Officers Examiner. Containing Questions and Answers on all subjects prescribed for an officer's examinition; together with Rules to guide Boards of Examination. Col. Wm. H. Powell, U. S. Army. Third Edition, revised to date. New York: John Wiley & Sons. 1901.

Colonel Powell's work has done much to aid officers in preparing for their examination for promotion, and in studying the subject of their profession. The present work is well known to the older officers and can be recommended to the younger, not only to assist them in preparing for examination, but also to guide them in their studies throughout their military service.

The best of such hand-books do not enable an officer to cram simply, but give him a general idea of the questions he is liable to be asked, and enable him to examine himself on the different subjects of his profession from time to time. Colonel Powell's book is of this kind.

This third edition is not, however, as recent and up-to-date as it might be made. Apparently only the addition of the values assigned to the questions to be asked is new. Some of the subject have not changed, but the Summary Court, for example, is very different from what is was when the questions in the text were framed. The addition of G. O. 100 of 1863, and of several other orders required under Military Law would have been really useful. Since the questions are many of them quite different from those actually put by Boards, the values assigned are of no great use.

Nevertheless, any one familiar with the contents of this work should be able to pass an excellent examination, and for that reason it is an essential part of an officer's library. J. P. W.

Théorie et Tracé des Freins Hydrauliques. M. E. Vallier, correspondent de l'Institut. Paris: Vve. Ch. Dunod, Editeur. 1900. Four Francs.

This pamplet, comprising matter originally published in the *Revue de Mécanique*, is an excellent exposition of the theory of action of hydraulic brakes or buffers.

The subject is introduced by a brief reference to friction brakes, and then the author passes at once to the general subject of hydraulic brakes, discussing first their elementary theory, next the theory of brakes with constant orifice and free discharge leading up to the loaded valve brake, under which are considered the Rendel (English) and the Krupp brakes.

Under constant pressure brakes, the Vavasseur receives considerable attention, also the Gruson; the disadvantages of these sliding valve brakes being fully considered and discussed. The Elswick piston-brake lead up to the Canet central counter rod system, to which a few examples of Krupp brakes, involving the same principles, are added.

The second chapter contains a new theory on hydraulic brakes, which makes an interesting theoretical study.

The third chapter is devoted to recuperator brakes, counterweight recuperators being illustrated by the Morgan and Buffington (or Bethlehem), spring recuperators by the Canet, the other forms including the Vickers, Meigs and

Stout, Schneider-Canet, the French navy and artillery brakes, and many others.

The theories of spring brakes and hydro-pneumatic brakes are also discussed in interesting chapters.

Each brake is fully illustrated, and the whole work constitutes an excellent and valuable study for the artillery constructor. J. P. W.

Notre Armeé: Essais De Psychologie Militair. Commandant Emile Manceau, Laureat De L'Institut. Paris: Bibliotheque-Charpentier. 1901, Pp. 425. 3.50 Francs.

This work is a philosophic essay on the French army, her military institutions, her officers, non-commissioned officers, privates, and finally her organization. It is written in a democratic spirit, freely criticising the existing system and suggesting changes in every direction.

In discussing the spirit of the French institutions he lays stress on the fact that now-a-days the army knows little of Napoleon, the man of magnetic power in the army and a real chief, but bases everything on Moltke, a commander without personal effect on his troops, keeping himself in the shadow, content to judge and inspire by his thought alone. He is impressed with the necessity for decentralization, to give greater independence of thought and action.

The excessive amont of *regulations* of all kinds is held up to the French and these regulations are severely contrasted with the brevity of those of the German army, at the same time showing their effect in taking away from the army the spirit of the initiative.

The officers, he claims, are not equal to their duties. Part of the trouble arises from the fact that one-third of the appointments to the grade of commissioned officers must come from the promotion of non-commissioned officers, which, in spite of the many schools for non-commissioned officers, results in giving the army a great number of uneducated officers.

The book is well worth study and consideration, especially by military men, who can appreciate the points made by the author, as many of them apply in a degree at least to all armies. Promotion for merit is one of the points particularly emphasized, but the problems connected therewith have in all time baffled the lawmakers.

On the whole it is a wholesome, readable volume, perhaps a little pessimistic as regards the present French army, but written in a spirit of advancement and evident sincerity for the good of the nation. J. P. W.

Views of Sandhurst Military College, Staff College, York Town and Camberley. Aldershot: Gale and Polden, Ltd. One Shilling.

A pamplet, eight by twelve inches, comprising a brief account of the military college and the staff college, together with descriptions of the neighboring towns of Camberley and Yorktown. The illustrations cover twenty-five pages, and are from photographs taken on the spot. The whole presents an interesting picture of life at these places. J. P. W.

Official Medals and Ribbons of the British Army, 1800 to present day. London and Aldershot: Gale and Polden, Ltd. Two Shilling and Six Pence.

A sheet showing both sides of forty-eight different medals, in colors. A most interesting collection, beginning with the general service medal 1773-1814 and ending with the South African Medal 1899-1900-1901. Perhaps the best known of these British medals are the Victoria Cross, the Ashantee Star, the Waterloo medal, and the different Soudan and Afghanistan medals.

J. P. W.

L'Artillerie à L'Exposition. Colonel X. Paris : Vve. Ch. Dunod, Editeur. 1901. 7.50 Francs.

A most complete record of the artillery material at the Paris Exposition, splendidly illustrated with over two hundred illustrations. containing not a mere summary of what was exhibited, but an intelligent, connected and detailed explanation of the special significance of each gun, carriage, breech-mechanism or turret, written by an expert on the subject.

The first part describes in a general way the exhibits of Germany, Great Britain, Austria, France and Russia ; and the second part discusses more in detail the various kinds of breech-blocks (fourteen in all), field and mountain carriages (six), siege and position carriages (four), coast carriages (four) naval, carriages (four), turrets (four), automatic guns and machine guns. Some of the illustrations, giving details of construction, are line cuts, but many are from photograps on a large scale. All are very clear and easily comprehended.

The work constitutes an excellent résumé of the principal modern artillery material, and will be invaluable to the student of artillery. J. P. W.

Le Nouveau Matérial d'Artillerie de Campagne Suisse, Modèle 1901. Lieut. Col. Ed. Manuel. Lausanne: Revue militaire suisse. Pp. 18, with four phototype plates. One Franc.

This pamplet gives a reliable and detailed description of the new field artillery material adopted by Switzerland. It is written by Lieutenant-Colonel Ed. Manuel, commandant of the parc of the First Corps.

The introduction contains a brief historical outline of the studies which led up to the present material. The latter is clearly described and well illustrated. The work will be of interest to artillerists as a study, and to military men generally who would naturally wish to acquaint themselves with the material actually in use by the world's armies. J. P. W.

L' Armement de L' Infanterie. Apercu Historique. Colonel Rubin. Lausanne: *Revue Militaire Suisse.* 1901. Pp. 57, with many tables and plates. Two Francs.

Colonel Rubin, the author of this interesting study, is the Director of the Arsenal at Thoune, where the Swiss small arms and ammunition are manufactured, and was placed in charge of the section at the Paris Exposition devoted to infantry arms. This historical study was intended as a guide to that exhibit, but is really an excellent history of the development of the infantry arm, especially as regards weight, rate of fire, muzzle velocity, accuracy, and penetration, and is well worth study by all. J. P. W.

Kriegsgeschichtliche Beispiele ans dem deutsch-franzoesischen Kriege von 1870-71. Kunz, Major a. D. Zwoelftes Heft. Berlin: E. S. Mittler & Sohn, 1900. Pp. 157. Price, 3.50 marks.

The present number of this valuable series of studies on the war of 1870-71 contains examples illustrating the deeds of individuals in battle and in the service of security and information of the infantry.

These examples are not mere acts of personal bravery, but are true tactical studies since they illustrate acts of battalions and other sub-divisions as well as of single individuals, and in both emphasize good judgment under trying conditions in all the various applications of tactics.

The first seventeen pages of the work contain examples of individual deeds of non-commissioned officers and men, the next five of those of First Sergeants; then follow fourteen pages devoted to the work of lieutenants in the field.

Prominent acts of platoons and companies are next taken up, foilowed by exampes of various kinds, such as a severe outpost fight, resisting an assault on the outposts, restoring order and quiet in battle, attack on a village, etc. Specially interesting episodes in the larger battles are described in detail and furnish much interesting information.

The other side of war is also presented in thirty examples of disaster to the German arms.

Finally, the subject of tactics is more definitely considered in the examples of the success of flank fire, of ammunition supply, and of the use of volleys.

Throughout the work the applications of tactics are apparent, and even from the most trivial incident as here presented a tactical lesson can be learned, or at least a lesson which will assist the military student in the practical application of tactics. On the whole, however, this number is of a more popular character than any of its predecessors, and consequently of less military scientific interest. But it is well worth study, nevertheless, and to the general reader it is of deep interest, constituting as it does a kaleidoscope of thrilling events. J. P. W.

The Campaign in the Free State, and its Lessons. Major C. E. Caunter, Lancashire Fusiliers, Professor of Tactics, Royal Military College. London: Gale and Polden, Ltd. 1901. Pp. 38. Price Two Shillings.

This brief essay on the brilliant campaign of Lord Roberts from Enslin-Graspan to Bloemfontein, by the professor of tactics at the Royal Military College, constitutes a valuable addition to the literature of the subject.

The author, from his position at the Royal Military College, and his practical field experience as D. A. A. G., 6th Division, South African Field Force, was particularly well equipped for the work.

He divides his subject into three parts: the topography and lines of communication, the operations, and the principal tactical lessons to be drawn. It is, on the whole, essentially a *tactical* study, by one thoroughly at home in the accepted principles of modern tactics, experienced in the field, and with good judgment and common sense. Consequently the lessons he attempts to inculcate are particularly valuable.

We will quote a few of the author's remarks: "In considering the tactical lessons that may be learned from the war, it is very necessary that we should constantly bear in mind that this campaign was fought in an exceptional country against an exceptional enemy."

"Throughout the campaign, cavalry were hardly ever called upon to perform the functions usually assigned to that arm in modern warefare."

"We have learnt that a complete understanding between the artillery and infantry, as previously alluded to, is essential to success."

"We have already seen that as a result of the long range and rapidity of fire of the modern rifle, the tendency, both on the offensive and defensive, is to occupy a much larger front, in proportion to the troops at disposal, than formerly. As a consequence, the distances that must necessarily be covered to execute a flanking or enveloping movement are correspondingly increased, and, in carrying out such duties as these, mounted infantry are indispensable."

This will suffice to indicate the general character of the author's comments, but we are sorry that lack of space prevents us from quoting them entire, as they are all lessons worth learning and taking to heart. J. P. W.

Kriegsgeschichtliche Beispiele des Festungskrieges ans dem deutsch-franzoesischen Kriege von 1870-71. Frobenius, Oberstleutnant a. D. Viertes Heft. Berlin: E. S. Mittler und Sohn. 1900. Pp. 88. Price 3.75 marks.

The fourth number of this interesting series of studies in the attack and defense of fortifications, continues the subject in the spirit of its predecessors.

The artillery attack is the special subject considered, and under this the first section treating of the attack with the means ready at hand in the field army.

The attack of Verdun, August 24, is first described, with comments, followed by an account of the attack on Toul, August 16.

The bombardment of fortified places, by means of field artillery alone, is illustrated by ten examples.

The whole series is an excellent tactical study, and will prove invaluable for field artillery officers. J. P. W.

Studien ueber Kriegfuehrpng auf Grund des Nordamerikanischen Sezessionskrieges in Virginien. Freiherr v. Freytag-Loringhoven, Major im Grossen Generalstabe. Erstes Heft: Bull Run, Richmond, Manassas. Berlin: E. S. Mittler und Sohn. 1901. Pp. 134. Price, 3.60 marks.

The study of our civil war by an officer of the Great General Staff of Germany should not surprise us, for the German army was much blamed by the older officers of our army for not having taken its lessons to heart in 1864, 1866 and 1870-71, and it has often been remarked by our military writers that they had to learn many a lesson even as late as 1870, by hard experience in the field, which, had they studied our war, would have been spared them. Unfortunately, they looked upon our civil war as one waged by untrained militia, and therefore of no immediate use to them. But today our civil war is recognized as one well worth study and consideration by the trained armies of Europe, as the historical predecessor of the wars of 1864, 1866 and 1870.

This first number of the series discusses the campaigns of Bull Run, Richmond and Manassas. The author's comments are evidently founded on close study, and are entirely without prejudice. In discussing the battle of Bull Run the author makes comparisons with the state of affairs on Long Island when Washington suffered his defeats there, as well as with the Prussian volunteers of 1813 and also Macdonald's defeat on the Katzbach (Naapoleon's forces at that time being largely composed of recruits).

Again, the campaign against Richmond, involving as it did the transportation of troops by water, leads the author to make some interesting comparisons with the transportation of German troops to China in 1900, of French and English troops to the Crimea in 1854, of Napoleon's Egyptian expedition in 1799, and of Japan's expedition to Port Arthur in 1894.

Finally, the campaign of Manassas with all the interference from Washington, leads to a comparison with the state of affairs in the French Republic when Gambetta was dictator.

These comparisons are original and interesting, but, of course, the strategical and tactical principles involved are fully discussed at all stages of the campaigns and battles.

There are three plans in the text and four maps are appended.

Such a series of studies by a trained soldier and a military writer of considerable reputation, should command attention, but particularly in our own country. J. P. W.

Der Freiheitskampf Nordamerikas und der Burenkrieg. Vortrag, gehalten in der Militärischen Gesellschaft zu Berlin am 20. März, 1901. H. Beseler, Generalmajor und Oberquartiermeister. Berlin: E. S. Mittler und Sohn. 1901. Pp. 36.

Major-General Beseler here presents a comparison between the American Revolution and the Second Boer War, the main idea being to set forth the necessity that Great Britain change from the system of voluntary enlistments to the Continental compulsory service system.

The essay is a strong argument in favor of the present standing army for Germany, but, in view of the ultimate success of Great Britain in South Africa she will hardly be tempted to try so complete a change of organization for the British army as the author declares necessary for her future existence.

On the whole the pamphlet is a readable and forcible study, and will at least lead to the correction of many minor defects in the future organization and training of the British army. J. P. W.

The Militia: a plea for increased efficiency. Major H. S. Lefroy-Stein, late 2nd in command 6th Bn. Rifle Brigade (P. C. O.). Aldershot: Gale and Polden, Ltd. Price: Sixpence. Pp. 30.

The author of this pamphlet sets forth in strong terms the defects in the present Militia, especially the lethargy of the older officers, and the lack of knowledge of field engineering, topography and tactics, and his remedy is to compel militia officers to pass the same examination on "Duties in the Field" as the regular officer, to adopt the sound *policy of selection* for command and promotion, and to increase the length of the term of training. J. P. W.

Führing und Verwendung der Divisions-Artillerie einer Infanterie-Truppen-Division. Gustav Smekal, K. und k. Major des Generalstabs-Corps. Vienna: L. W. Seidel & Sohn. 1901. Pp. 130, with 12 maps.

This work on the handling of the artillery attached to a division, by Major Smekal of the Austrian General Staff, is in reality a tactical study, or more accurately a series of connected tactical problems.

These problems were mostly discussed and solved by the author *in the field.*

The method of treatment, consists in first stating the general situation, then setting a number of problems and finally solving them.

The situation assumed is as follows:

"The pursuit of the enemy, who was beaten yesterday east of Baden and retired towards Vienna, will be continued today."

"For this purpose the 1st division will advance from Gumpoldskirchen over Mödling, the 4th cavalry division from Neudorf towards Meidling.

"On the high road from Münchendorf over Laxenburg and eastward the main body of our army will follow."

Then follows the composition of the 1st Infantry Division.

The first problem discussed the grouping of the 1st infantry division for the pursuit, and especially the subdivision and the duties assigned to the divisional artillery.

The second considers the opening of the artillery reconnoissance on the evening preceding the battle.

And so on, each phase of the situation furnishing material for a new problem.

The entire work constitutes an excellent training school for a field artillery officer, especially one aspiring to high rank and the command of the artillery of an infantry division.

The proper wording of orders for clearness and brevity is one of the features of the study, and the whole presents a very fair picture of the work required of the artillery in a modern campaign.

There are twelve separate maps attached for use in connection with the problems.

J. P. W.

Grundsätze für die Durchführung des artilleristischen Aufkläringsdienstes. Gesammelt von George Sprang, k. u. k. Major im Divisions-Artillerie-Regimente No. 8. Vienna: L. W. Seidel & Sohn. 1901. Pp. 39. Price 3 K.

Military history has proven the necessity for field artillery reconnoissance. The general introduction of smokeless powder with its consequent invisible shot has made surprises by the enemy's fire far more numerous and serious, and has rendered the determination of the enemy's position and the selection of one's own artillery position more difficult than formerly, unless thorough preliminary reconnoissance be resorted to.

The principles involved in this reconnoissance are set forth in the above work in clear, terse language. It is impossible to summarize these principles as the entire pamphlet is in reality such a summary, but it may be stated that the author sets forth the object and scope of the service required, the points to be attended to, the early beginning necessary, the further work required as the battle proceeds, the system of transmission of intelligence and the technical and tactical principles involved at every stage.

It is a pioneer in this field and deserves careful study and consideration.

J. P. W.

Practical Hints for Mounted Infantrymen. By Lieut. B. L. Anley, late Adjutant 6th Regiment Mounted Infantry. Aldershot: Gale and Polden, Ltd. Pp. 40. Price Sixpence.

This little pamphlet is particularly useful in indicating the kits found most useful for officers and men in countries like South Africa, and also the tactics of scouting. It is based on the author's own experience in the field and is full of interesting information for officers and men in general. It also contains some original ideas on formation in camp and bivouac and for advance and flank guards.

J. P. W.

BOOK NOTICES.

[These books will be fully *reviewed* as space becomes available.]

Questione di massima concernenti gli attrezzi di puntamento e tiro per le odierne artiglierie campali. Giuseppe Capello, Capitano d' Artiglieria, Allessandria: Librario G. M. Piccone. Pp. 14. Price 0.50 Lire.

Organization et Composition des Troupes du Genie et de l'Etat-Major de Cette Arme. Par le Lt. General Brialmont. Liege: Revue de l' Armee Belge. 1901.

INDEX TO CURRENT ARTILLERY LITERATURE.

PERIODICALS CITED.

Abbreviations employed in index are added here in brackets.

All the periodicals are preserved in the Artillery School Library, Fort Monroe, Virginia.

ENGLAND.

Aldershot Military Society. *Occasional.*
Aldershot. Copies 6*d each.*

Arms and Explosives. [*Arms and Ex.*] *Monthly.*
Effingham House, Arundel Street, Strand, London, W. C. Per year 7*s.*

Army and Navy Gazette. [*A. and N. Gaz.*] *Weekly.*
3 *York Street, Covent Garden, London. Per year* £1 12*s* 6*d.*

Canadian ilitary Gazette. [*Can. Gaz.*] *Fortnightly.*
Box 2179 *Montreal, Canada. Per year* $2.00.

The Engineer. [*Eng.*] *Weekly.*
33 *Norfolk Street, Strand, London. Per year* £2 6*d.*

Engineering. [*Eng'ing.*] *Weekly.*
35-36 *Bedford Street, Strand, London, W. C. Per year* £2 6*d.*

Journal of the Royal United Service Institution. [*Jour. R.U.S.I.*] *Monthly.*,
22 *Charing Cross, Whitehall, London, S. W. Per year* 24 *s.*

Journal of the United Service Institution of India. [*Jour. U. S. I. India*] *Quarterly.*
Simla, India. Per year $2.50.

Military Mail. [*Mil. Mail.*] *Weekly.*
2, *Amen Corner, E. C., London, England. Per year* 8 *Sh.*, 8 *pence.*

Photographic Journal. [*Photo. Jour.*] *Monthly.*
66 *Russell Square, London.*

Proceedings of the Institution of Civil Engineers. [*Proceedings I. C. E.*]
25 *Great George Street, Westminister, London.*

Proceedings of the Institution of Mechanical Engineers.
[*Proceedings I. M. E.*] 19 *Victoria Street, Westminister, London.*

Proceedings of the Royal Artillery Institution. [*Proceedings R. A. I.*] *Monthly.*
Woolwich, England.

Professional Papers of the Corps of Royal Engineers.
[*Prof. Papers Corps Royal Eng'rs.*] *Chatham, England.*

Review of Reviews. [*Rev. of Rev. Austral.*] *Monthly.*
169 *Queen Street, Melbourne, Australia. Per year* 11 s. 6 d.

Transactions of the Canadian Institute. [*Trans. Canadian Inst.*]
58 *Richmond Street, Toronto, Canada.*

Transactions of the Canadian Society of Civil Engineers.
[*Trans. Canadian Soc. C. E.*]
Montreal, Canada.

Transactions of the East of Scotland Tactical Society.
[*Trans. E. of S. Tactical Soc.*]
51 *Hanover Street, Edinburgh, Scotland.*

Transactions of the Institute of Naval Architects.
[*Trans. Inst. Naval Architects.*]
5 *Adelphi Terrace, London, W.C.*

United Service Gazette. [*U. S. Gaz.*] *Weekly.*
10, *Wine Office Court, Fleet Street,London, E. C.* *Per year* £1 10 *s* 6 *d.*

United Service Magazine. [*United Serv. Mag.*] *Monthly.*
13 *Charing Cross, S. W. London.* *Per year* 27 *shillings.*

FRANCE.

Armée et Marine. [*Armée et Mar.*] *Weekly.*
3 *Place du Théatre Français, Paris, France.*

Le Génie Civil. [*Génie C.*] *Weekly.*
6 *Rue de la Chaussée d Antin, Paris.* *Per year* 45 *Fr.*

Le Livre Militaire. [*Livre Mil.*] *Monthly.*
6 *Rue de la Chaise, Paris.* *Per year* $1.00.

La Marine Française. [*Marine F.*] *Semi-monthly.*
26 *Rue de Grammont, Paris.* *Per year* 30 *Fr.*

Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils.
[*Ingénieurs Civils.*] *Monthly.*
10 *Cité Rougemont, Paris.* *Per year* 36 *Fr.*

Mémorial des Poudres et Salpêtres. [*M. Poudres et S.*] *Quarterly.*
Quai des Grands-Augustins, 55, *Paris.* *Per year* 12 *Fr.*

Le Monde Militaire. [*Monde.*] *Fortnightly.*
6 *Rue de la Chaise, Paris.* *Per year* 8 *Fr.*

Revue d'Artillerie. [*R. Artillerie.*] *Monthly.*
5 *Rue des Beaux-Arts, Paris.* *Per year* 22 *Fr.*

Revue de Cavalerie. [*R. Cav.*] *Monthly.*
Berger Levrault et Cie, Rue des Beaux-Arts 5, *Paris.* *Per year* 33 *Fr.*

Revue du Cercle Militaire. [*Cercle.*] *Weekly.*
37 *Rue de Bellechasse, Paris.* *Per year* 27 *Fr.*

Revue du Génie Militaire. [*Génie M.*] *Monthly.*
8 *Rue Saint-Dominique, Paris.* *Per year* 27 *Fr.*

Revue d'Infanterie. [*R. Inf.*] *Monthly.*
11 *Place Saint André-des-Arts, Paris.* *Per year* 25 *Fr.*

Revue Maritime. [*R. Maritime.*] *Monthly.*
L. Baudoin, Rue et Passage Dauphine 30, *Paris.* *Per year* 56 *Fr.*

Revue Militaire. [*R. Mil. France.*] *Monthly.*
R. Chapelot et Cie., 30 *rue et passage Dauphine, Paris.* *Per year* 20 *Fr.*

Revue Militaire de l'Etranger. [*Etranger.*] *Monthly.*
L. Baudoin, Rue et Passage Dauphine 30, *Paris.* *Per year* 15 *Fr.*

Revue Militaire Universelle. [*R. Univ.*] *Monthly.*

Revue des Questions Militaires. [*Quest. Mil.*] *Monthly.*
6 *Rue de la Chaise, Paris.* *Per year* $3.00.

11 *Place Saint André-des-Arts, Paris.* *Per year* 25 *Fr.*

Le Yacht—Journal de la Marine. [*Yacht.*] *Weekly.*
55 *Rue de Chateaudun, Paris.* *Per year* 30 *Fr.*

GERMANY.

Allgemeine Militaer-Zeitung. [*A. M.-Zeitung.*] *Semi-weekly.*
Darmstadt. Per year 24 *M.*

Beiheft zum Militaer-Wochenblatt. [*Beiheft.*]
Koch Strasse, 68, *S. W., Berlin.*

Deutsche Heeres-Zeitung. [*Heeres-Zeit.*] *Semi-weekly.*
Wilhelmstrasse 15, *Berlin. Per year* $6.00.

Deutsche Land und Seemacht daheim und in den Kolonien. [*Land u. Seemacht.*] *Fortnightly.*
Eisenacherstrasse 60–61, *Berlin, W.* 30. *Per Quarter* 6 *M.*

Illustrirte Aeronautische Mittheilungen. [*Aeronaut. Mitth.*] *Quarterly.*
Kalbgasse 3, *Strassburg i. E. Germany. Per year* $1.70.

Internationale Revue. [*Int. Revue.*] *Monthly.*
Blasewitzer Strasse 15, *Dresden. Per quarter* 8 *Fr.*

Jahrbuecher fuer die deutsche Armee und Marine. [*Jahrbuecher.*] *Monthly.*
Mohren Strasse, 19, *Berlin, W.* 8. *Per year* 32 *M.*

Kriegstechnische Zeitschrift. [*Kriegstech.*] *Ten numbers a year.*
Koch Strasse, 68-71, *Berlin. Per year* 10 *M.*

Marine Rundschau. [*Mar. Rundschau.*] *Monthly.*
Koch Strasse, 68-70, *Berlin. Per year* 3 *M.*

Militaer-Wochenblatt. [*Wochenblatt.*] *Semi-weekly.*
Koch Strasse, 68, *Berlin, S. W.* 12. *Per Year* 20 *M.*

Stahl und Eisen. [*Stahl u. Eisen.*] *Fortnightly.*
Schadenplatz 14, *Düsseldorf. Per year* $5.00.

Umschau, Die. [*Umschau.*] *Weekly.*
Frankfort a. M. Per year 10 *M.*

AUSTRIA.

Mittheilungen ueber Gegenstaende des Artillerie und Genie-Wesens. [*Mitth. Art. u. G.*] *Monthly.*
Wien, VI, Getreidemarkt 9. *Per year* 1 *Fl.* 50 *Kr.*

Mittheilungen aus dem Gebiete des Seewesens. [*Seewesens.*] *Monthly.*
Pola. Per year 14 *M.*

Organ der Militaer Wissenchaftlichen Vereine. [*Vereine.*]
Wien I, Stauchgasse No. 4. *Per year,* 8-14 *numbers,* 6 *Fl.*

Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines. [*Z. Architek. Ver.*] *Weekly.*
I. Eschenbachgasse, No. 9, *Wien. Per year* 10 *Fl.*

SWITZERLAND AND BELGIUM.

Allgemeine Schweizerische Militaer-Zeitung. [*A.S.M. Zeitung.*] *Weekly.*
Basel, Switzerland. Per year, 8 *Fr.*

La Belgique Militaire. [*Belgique M.*] *Weekly.*
Rue St. Georges 32, *Ixelles, Belgium. Per year* 12.50 *Fr.*

Monatschrift fuer Offiziere Aller Waffen. [*Monatschr.*] *Monthly.*
Frauenfeld, Switzerland. Per year 5 *Fr., plus postage.*

Revue de l'Armée Belge. [*A. Belge.*] *Bi-monthly.*
22 *Rue des Guillemins, Liège, Belgium. Per year* 13 *Fr.*

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THE DEVELOPMENT OF THE MODERN FIELD GUNS.

By CAPTAIN WILMOT E. ELLIS, Artillery Corps.

INTRODUCTION.

During the twenty years succeeding the Franco-Prussian War, there was practically no transformation of field artillery material. At the end of these two decades the method of correcting defects by constructing new "models" (which were in reality but new editions of old types) was becoming impracticable. The time of a complete transformation was at hand. The period 1890-1892 marks the obsolescence of the old systems, and the inauguration of the thorough discussion which has culminated in the general re-armament now practically completed.

It is proposed in this paper to accept as accomplished facts the systems of field artillery existing in the year 1890-1891, and to trace the development of the field gun from that period to the present. In order to clear the way for this task, it will be advisable to note the various methods proposed for measuring the tactical and ballistic efficiency of field guns.

The following nomenclature will be used:

ω—the weight of the powder charge in pounds.
w—the weight of the projectile in pounds.
W—the weight of the gun in pounds.
W_1—the weight of the gun carriage in pounds.
W_2—the weight of the limber (filled) in pounds.
W_3—the weight of the caisson (filled) in pounds.
m—the total weight of shrapnel balls and fragments of regular separation, (the French "mitraille") in pounds.
p_1—the weight of the projectiles in pounds carried in the limber.
p_2—the weight of the projectiles in pounds carried in the caisson.

V—the muzzle velocity in feet per second.
E—the muzzle energy in foot-tons.
d—the caliber in inches.
s—the area of the cross-section of the projectile in square inches.
R—the "rendement," variously called "factor of efficiency," "factor of effect," and "duty." The French term which is more expressive will be used. The letter "R" will be employed with various subscripts, which wil be explained in each case.

For the muzzle energy, we have :—

$$E = w\, V^2/2g \times 2240 \quad \text{or} \quad w\, V^2/144256 \quad \text{or}$$

$$E = w\, V^2/(5.15913) \tag{1}$$

This measure may also be expressed in another way. Let P be the mean pressure of the powder gases in pounds per square inch, and u the travel of the projectile in the bore in feet. Then,

$$E = P\, s\, u/2240$$

For a given powder and travel of projectile, the ratio of the maximum pressure to the mean pressure is practically constant. If we represent this ratio by β and the maximum pressure by P_m, we may write :—

$$P_m = \beta P,$$

$$\text{and } E = P_m\, s\, u/2240\beta \tag{1^1}$$

With the old powders, the value of β was about 3. With modern smokeless powders, β approximates 1.5, and this value at present seems to be the inferior limit.

The absolute rendement, R_a, is the ratio of the kinetic energy of the projectile to the potential energy of the charge of powder :

$$R_a = 2240\, E/C\,\omega\, 778, \quad \text{or} \quad R_a = 2.88\, E/C\,\omega \tag{2}$$

in which C is the number of units developed by the combustion of one pound of powder.

The rendement of the gun, R_g, is the quotient obtained by dividing the muzzle energy by the weight of the gun, or :—

$$R_g = 2240\, E/W \tag{3}$$

Similarly the rendement of the gun in battery, R_b, will be

$$R_b = 2240\, E/W + W_1 \tag{4}$$

Alternative forms for all of these rendements could be obtained by the application of equation (1^1), but they would be of little practical use.

The "sectional density" is a term too well known to require any explanation. "Spherical density" is now generally used to compare the carrying power of different projectiles. It is the ratio of the weight of the projectile to a solid spherical projectile of the same caliber.

The expression for the spherical density depends upon the value assumed for the specific gravity of iron. Taking this as 7, the number adopted by Captain Moch, 1 cubic inch of iron will weigh 0.2529 pounds. The weight of a spherical ball for a given caliber will then be $d^3 \pi/6 \times .2529 = .1324\, d^3$. For the spherical density, we have

$$S.D. = 7.552\ w/d^3 \quad \text{or} \quad (0.87808)\ w/d^3 \tag{5}$$

The next measures to be considered are the ammunition rendements. The rendement of a shrapnel, "interior rendement," is the ratio of the weight of the charge of bullets and fragments of regular separation to the total weight of the shrapnel. The projectile rendement of the limber is the ratio of the weight of projectiles carried to the total weight of the limber loaded, and similarly for the caisson. We may write :—

$$R_i = m/w \tag{6}$$

$$R_{lr} = p_1/W_2 \tag{7}$$

$$R_{cn} = p_2/W_3 \tag{8}$$

It is generally admitted that the typical projectile for field artillery is the shrapnel. The efficiency of shrapnel fire for a given remaining velocity depends upon the number of enclosed balls or fragments of each projectile, upon the distance at which the projectile bursts short of the target, and upon the rapidity of fire.

We may assume :

1. The projectile should be so organized as to produce the maximum destructive effect.

2. This effect should be produced in the minimum of time, or with the minimum expenditure of ammunition, or preferably of both.

Colonel Langlois calls the rendement of fire ("rendement dans le tir") the ratio of the number of hits, n, to the weight of the projectile, w. In other words, the rendement of fire is the number of hits per pound of projectile, or :—

$$R_f = n/w \tag{9}$$

This is not an absolute measure since at each range n depends upon the form and dimensions of the target.

In firing against an extended line, as a line of skirmishers, the number of hits, n, is to the total number of balls and fragments, *N*, as the diameter of the zone of dispersion is to the area of its cross-section. We have then :

$$n : N :: I \tan \tfrac{1}{2}\,\theta : \pi\, I^2 \tan^2 \theta$$

in which *I* is the distance in yards at which the projectile bursts short of the target, and θ is the angle of opening of the cone of dispersion. From the above proportion, we deduce :

$$n = N/\pi\, I \tan \tfrac{1}{2}\,\theta \quad \text{or} \quad .318\, N/I \tan \tfrac{1}{2}\,\theta$$

Assuming as the normal interval of bursting, I_n, that at which the number of hits upon the target is one per square yard, the area of the circle that represents this section will be equal to the number of balls, or :—

$$N = \pi\, (I_n \tan \tfrac{1}{2}\,\theta)^2$$

From the above expression, we deduce :

$$I_n = \sqrt{N}/\tan \tfrac{1}{2}\,\theta \sqrt{\pi} \quad \text{or} \quad I_n = .57 \sqrt{N}/\tan \tfrac{1}{2}\,\theta \qquad (10)$$

General Wille deduces the following formula based upon experimental firing with the German field gun :

$$\tan \frac{\theta}{2} = \frac{\sqrt{h^2 + v^2 \sin^2 \rho}}{v + h^1} \qquad (11)$$

in which *v* is the velocity of the projectile at the point of bursting, *h* the radial velocity, h^1 the forward velocity due to the bursting charge, and ρ is the angle of rifling at the muzzle. (General Wille's nomenclature has been slightly modified so as to conform that to the one that I have adopted.)

Combining (10) and (11), there results :

$$I_n = \frac{.57 \sqrt{N}(v + h^1)}{\sqrt{h^2 + v^2 \sin^2 \rho}} \qquad (12)$$

If we divide the rendement of fire (R_f) of a given light projectile by that of a given heavy projectile, the quotient will be the number of pounds of the heavy projectile corresponding to one pound of the light projectile. Multiplying this number by 100, we find the number of pounds of heavy projectiles corresponding to 100 pounds of the light. These weights divided by the weights of the respective projectiles give the number of light and the number of heavy producing the same effect.

Let *e* represent the energy of recoil of the gun, and e_1 the energy of recoil of the gun in battery,—both in foot pounds. We may write :

$$e = (w + a\,\omega)^2\, V^2/2\,g\, W \qquad (13)$$

$$e_1 = (w + a\,\omega)^2\, V^2/2\,g\, (W + W_1) \qquad (14)$$

in which *a* is the fractional part of the charge that is blown out with the projectile. Equation (13) may be written :

$$e = (2240\, E\, w / W) \times (w + 2 \alpha \omega + \frac{a^2 \omega^2}{w}) \tag{14}$$

or as $R_g = 2240\ E/W$, and making n^1 equal to $\frac{\omega}{w}$ we have

$$e = R_g\, w\, (1 + a n^1)^2 \tag{15}$$

Assuming Piobert's value of a, 1/2, the above expression becomes:—

$$e = R_g\, w\, (1 + \frac{n^1}{2})^2 \tag{16}$$

As n^1 is ordinarily small, not exceeding 0.2 with the best powders, we may write approximately:

$$e = R_g\, w \tag{17}$$

a very convenient measure. We therefore conclude that the energy of recoil of the gun is equal to the gun rendement multiplied by the weight of the projectile.

Similarly, we obtain:

$$e = R_b\, w\, (1 + \frac{n}{2})^2 \text{ and}$$

$$e_1 = R_b\, w \tag{18}$$

From which we conclude that the energy of recoil of the gun and carriage is equal to the rendement of the gun in battery multiplied by the weight of the projectile.

The energy of recoil of the piece is transmitted to the carriage, and is separated into two parts. One is the energy of the piece in battery, e_1, and must be absorbed by the friction of the carriage upon the ground. The other part, $e - e_1$ is absorbed by the carriage.

We have the relations:

$$e : e_1 :: R_g : R_b :: W \times W_1 : W, \qquad \text{whence}$$

$$e - e_1 = e_1\, W_1 / W \tag{19}$$

As most of the stress should be transmitted to the ground, the energy absorbed by the carriage should be minimized. This may be effected by increasing the weight of the gun relative to the carriage.

By dividing the energy of recoil of the gun by the weight of the carriage, we obtain the stress per pound of carriage, assuming the carriage to be rigid. This is an important measure, and may be expressed:

$$S = e / W_1 = \frac{R_g\, (1 + \frac{n}{2})^2\, w}{W_1} \text{ or (approximately)}$$

$$S = R_g\, w / W_1 \tag{20}$$

That is, the carriage stress per pound of carriage is approximately equal to the rendement of the gun multiplied by the ratio of the weight of the projectile to the weight of the carriage.

To deduce an expression for the length of recoil, let L represent the length in feet, and $I=(W+W_1)f$ the intensity of friction, f being the coefficient of friction. We have then:

$$L\,I = e_1 = R_b\,w\,(1+n/2)^2 \quad \text{and}$$

$$L = \frac{R_b\,w\,(1+n/2)^2}{(W+W_1)f} \text{ or, approximately,—}$$

$$L \mp R_b\,w/(W+W_1)f \qquad (21)$$

The recoil, then, is directly proportional to the rendement of the piece in battery and the weight of the projectile, and inversely proportional to the weight of the gun plus that of the carriage, and to the coefficient of friction.

The 'accompanying table gives the principal elements and rendements of systems of field artillery existing at the period 1890 91. The countries, selected as representative are Russia, Germany, England, Spain, and the United States. The table also includes data for field guns advertised or projected by the principal private manufacturers during the same period.

The figures for the U. S. 3.2-inch gun belong to a period somewhat later than the trantitional period that I have adopted, but are here introduced for purposes of comparison.

The Sotomayor gun, model of 1880, though originally intended for service with horse artillery, finds a place in the table because of its remarkable features. The adaptability of this gun to field artillery was soon recognized, and for over ten years it held its place as the most efficient field gun in service. It is worthy of note however, that Spain has put but few of the Sotomayor guns into service.

The high interior rendements of French shrapnel may be accounted for by the fact that, in the calculation, the fragments of the separator plates are included with the balls in determining "*m*". In the case of the U. S. gun, the rendements and and the number of balls for the Frankford Arsenal and the electrically-welded shrapnel are both given, and in the order named.

HIGH-POWER FIELD GUNS.

GENERAL WILLE'S PROJECT.

General Wille's celebrated book, "The Field Gun of the Future," was published at Berlin in 1891. The appearance of this book elicited so much criticism, favorable and unfavorable,

Field Guns (1890-1891).

	Russia Model 1877.	France 8-cm. Model 1877.	France 9-cm. Model 1877.	Germany 88 mm. Model 1873.	England 12-pdr. Model 1884.	Spain (Sotomayer's) Model 1880.	United States 3.2 inch.	Canet 75 mm. of 32 calibers.	Gruson 75 mm. of 30 calibers.	Hotchkiss 75 mm.	Krupp 75 mm. of 30 calibers.
Caliber (inches)	3.43	3.15	3.54	3.46	3.00	3.09	3.20	2.95	2.95	2.95	2.95
Muzzle velocity (feet per second)	1450	1526	1417	1368	1719	1509	1685	1640	1640	1739	1722
Weight of cannon (pounds)	1003	937	1168	926	783	639	800	794	794	791	904
Weight of gun carriage (pounds)	1184	1168	1631	1179	1378	705	1195	1102	1168	992	1124
Weight of piece in battery (pounds)	2187	2105	2799	2105	2161	1344	1995	1896	1962	1783	2028
Weight of limber (loaded) (pounds)	2030	1467	1867	2094	2028	2050	1770	1080	....	1653	1896
Weight of piece limbered loaded (pounds)	4217	3572	4660	4360	4180	3395	3765	2970	....	3435	3915
Weight of caisson (loaded) (pounds)	4475	4055	4850	4475	4255	4185	4500	2765	....	3440	....
Weight of shrapnel (filled) (pounds)	15.2	13.8	19.2	17.8	12.5	14.2	13.5	11.5	15.4	12	15.4
Spherical density $\frac{7.55^2 w}{d^3}$	2.86	3.35	3.25	3.23	3.50	3.61	3.11	3.36	4.53	3 59	4.53
Number of shrapnel balls	165	162	237	262	177	231	162 170	135	192	212	....
Number of rounds (per battery)	1280	936	846	808	648	832	1080 1386	792	....	....	....
Number of rounds (per piece)	160	156	141	134⅔	108	138⅔	180 231	132	......	....	....
Muzzle energy (foot-tons)	222.5	224.0	267.0	225.0	256.5	220.5	266.0	214.0	288.0	252.5	318.0
Energy of recoil of cannon (ft. lbs.)	9210	9285	12180	11860	12390	13895	12940	9035	13745	9150	13540
Carriage stress (in foot pounds per pound of carriage)	7.8	7.9	7.3	10.1	9.0	19.7	10.8	8.2	11.8	9.2	12.1
Rendement of gun—R_g	495	535	512	509	735	794	745	594	810	712	787
Rendement of piece in battery—R_b	227	238	213	240	266	367	299	253	331	315	351
Rendement of shrapnel—R_i	.25	.47	.51	.42	.41	.41	.29 .37	.53	.37	.55	....
Rendement of limber—R_{lr}	.23	.30	.26	.24	.22	.25	.32	.26	....	.35	....
Rendement of caisson—R_{cn}	.28	.29	.30	.28	.21	.24	.38	.29	....	....	....
Length of cannon over all (feet)	6.9	7.5	7.5	6.9	7.7	7.2	7.3	7.9	7.3	7	7.5
Maximum powder pressure (pounds per square inch)	20000	32500	31500	21500	26000	25500	35000	28500	29500	25000	....
Extreme range of shrapnel fire (yds)	3700	6350	6100	3850	3300	4250	......	4500	6550	....	....

that the author has since published several more works in the defense and elaboration of his original views.

The gun, proposed by this German officer is essentially a high-power, small-caliber gun with a flat trajectory. He was led to the determination of these characteristics by following two converging lines of thought. He assumes, first, that shrapnel fire in order to be decidedly effective must have a deep zone of efficiency; and secondly, that the development of the field gun will be analogous to that of the infantry rifle.

General Wille considers the following to be the essential elements of a system of field artillery: 1st—weight of projectile; 2d—caliber; 3d—sectional density; 4th—muzzle velocity; 5th—accuracy; 6th—the kind of projectiles and their allotment; 7th—the amount of ammunition to be carried by the battery; 8th—the mobility.

The sectional density is a corollary of the first two conditions. The ammunition carried by the battery and the mobility are mutually dependent. It is well settled that in future but two kinds of projectiles will be used, shrapnel and torpedo shell, the proper proportion of each being a tactical experiment. Accuracy is an element to be determined by trial only, and cannot be considered in a preliminary theoretical discussion.

The muzzle velocity is an element that principally concerns the constructor. The remaining velocity is the important element from the tactical point of view. In order however to secure a high remaining velocity at all practicable ranges, General Wille assumes for his ideal gun a muzzle velocity of 2625 f. s., *at least.* This high velocity increases the effective range, but little importance is attached to this fact.

In order to secure the best effect, the projectile should have a high sectional density. The weight for a given caliber is limited by the length, which should not be excessive. The length, including the fuze, is taken at 4.4 calibers, which corresponds to a sectional density of 2.39 pounds per square inch of cross section.

The weight of the projectile is quite a difficult matter to determine. If it is light and at the same time well-organized, this is a benefit that accrues to the ammunition supply. If, on the other hand, the projectile is heavy, the effect of the individual shot is thereby increased. Wille takes a mean of the extreme weights used in service and adopts a weight of 14.75 pounds. The assumptions already made determine the caliber, which is 2.76 inches.

By a comparison of existing systems and by calculation, the

General deduces 882 pounds and 1212 pounds as the weight of the gun and of the gun-carriage, respectively. He is satisfied from his personal experience and investigations that it will be possible to construct a carriage whose weight is 1212 pounds and which will stand the recoil of his 882-pound cannon.

The gun is to be preferably of the built-up type, the inner tube to be of Mannessmann rolled nickel steel. The rifling will be of the Maitland profile with an increasing twist, the pitch to be determined by experiment.

In order to reduce the stress upon his gun, the author has assumed the greatest length that can possibly be admitted by service conditions. This is taken as 9.2 feet with a length of travel of about 7 feet.

The mean powder pressure will be 33,500 pounds per square incn. Taking what seems to be the present limiting value of the ratio of the maximum to the mean pressure, 1.5, we deduce for the maximum pressure, 50,250 pounds per square inch. The General, however, neglects to furnish any figures relative to the maximum pressure. He simply states that he has great hopes of future improvement in gun construction and powder manufacture.

The Gruson falling-block breech mechanism is recommended as being the lightest and most efficient. This mechanism greatly resembles that of the Nordenfeldt rapid-firing gun.

On account of the high powder pressure, fixed ammunition is considered necessary in order to secure obturation. A cartridge case of brass rich in copper will be used, and the weight is assumed to be 17.5 ounces. The charge is to be 3 pounds of cubical smokeless powder.

The protectile will have a driving band in rear and a bourrelet in front. The shrapnel will have a steel envelope quite thin except in rear, where it will be thickened for the powder chamber. The projectile will be insured against "upsetting" by the use of longitudinal ribs of Mannessmann forged steel separating the exterior rows of balls. The balls are to be "set" in some kind of a sulphur composition until experience has shown that the interstices between the balls can be filled by the bursting charge, thus lessening the dead weight.

General Wille expects an interior rendement of 42% for his shrapnel. The bursting charge will be as small as possible. A charge of 1.5% of the total weight of the projectile will be sufficient to rupture the walls, and will furnish enough smoke to observe the effects of fire.

In order to secure the great weight of the shrapnell, it is proposed to use balls of tungsten with steel envelopes. The specific gravity of pure tungsten is 19.13. In commercial forms it runs from 17 to 18.5. Including the envelopes, the General estimates the specific gravity at 16. The density of the lead composition ordinarily used for shrapnel balls is when compressed about 9.5. The mean of the actual weights of various shrapnel balls is .46 ounces.

By adopting tungsten it will be possible to increase considerably the number of balls, the total weight remaining the same. For a ball of lead and for one of tungsten of the same weight, the resistance of the air will be in the ratio of about 10 to 7. Wille proposes 250 balls of .388 ounces or 340 balls of .282 ounces, whichever experience shows to be the most advantageous.

The torpedo shell should have a body of forged Mannessmann steel, the head to be screwed over the body. The bursting charge will be as strong as possible. The length and weight of the shell should be so selected that its trajectory sensibly coincides with that of the shrapnel.

The General thinks that canister should have no place in the ammunition chests. He cites the relative expenditures in recent wars as follows:

	Shell.	Shrapnel.	Canister.
Bavarians (1870-71).	95.46%	4.4%	0.14%
Saxons (1870-71).	88.88%	11.04%	0.08%
Russians (1877-78).	72.5%	26.8%	0.7%

The Prussian batteries in the War of 1870-71 carried 8% of canister, and in six months the average expenditure was only about one canister to every four pieces.

As a substitute for canister, he proposes that the normal adjustment for the shrapnel fuze should be zero, so that without any preliminary adjusting the projectile would burst about eighty feet in front of the gun. If howsver canister is to be retained, an elongated projectile with thin steel walls should be used. The balls should be of tungsten, the bursting charge light, and an old-fashioned base-fuze lighted by the flame of discharge is recommended.

Mechanical fuzes are preferred to those of composition as it is impossible to prevent deterioration of the latter. A fuze invented by Lieutenant de Roy of the Belgian artillery is highly commended by the author. This is an hydraulic fuze, the burst being determined by the flow or displacement of a certain mass of liquid in the interior.

General Wille lays down the following conditions, which should be fulfilled by hydraulic fuzes:

1. It should be possible to transport all the projectiles ready for firing (except the adjustment for range) without danger of premature explosion.
2. No adjustment should be necessary to use the shrapnel as canister.
3. The time element should anmit of suppression, when desired, in a simple manner, and without chance of error.
4. The interior liquid should be-out of all contact with the external air.
5. A rise of temperature should cause no undue stress upon any part of the fuze.
6. The meteorological conditions of the day should alter the time of flow in the same ratio as the time of flight.
7. The fuze must function without changing the weight of the projectile during flight, i. e.,—none of the liquid should escape to the outside.
8. The liquid should flow in channels symmetrically situated with reference to the projectile's axis so as not to affect the relative distribution of weight.
9. Up to the time of actual firing, it should be possible to modify at will the adjustment.
10. At all times it should be possible to test by a simple inspection the working condition of the fuze.

DETAILS OF THE CARRIAGE.

The width between wheels is to be the same as that of the German carriage. The axis of the trunnions should be 3.44 feet above the ground (German, 3.77 feet). By lowering the center of gravity there will be a resulting gain in stability and strength and an economy in weight.

The carriage will admit of a maximum elevation of 12 degrees (German,—16) with a range of 5500 yards. This is practically a limiting range, but in the rare cases where it might be desirable to fire at greater ranges, the necessary elevation could be obtained by sinking the trail.

Nothing should be carried upon the carriage except such articles as are actually employed in connection with firing. The carriage is thus relieved from extra weight, and is not weakened by the cutting away necessary to make and secure receptacles.

General Wille takes as his model the (then) latest type of Gruson carriage. The trunnions of the piece are supported in trunnion carriages which slide in a frame. This frame is supported in front by projections which encircle the axle, and in rear it rests upon the elevating screw. A lug projecting from the breech is attached to the piston of an hydraulic cylinder and to a spiral spring in front of the cylinder. The frame is so mounted that it is possible to give the piece a small lateral movement independent of the trail. The piece is automatically held from battery until released by a spring.

The trail and axle should be made of Mannessmann tubular steel. The author thinks that the trunnion fittings of the German carriage are weak and recommends the English method of covering the bearing surfaces by a bourrelet, thus excluding dust, and forming a true transom. He prefers however the suppression of trunnions and the use of a cradle.

The General disposes of nearly all the various types of brakes. He thinks that a friction clamp brake adopted for the 12-cm Krupp field mortar is the least objectionable. The ideal carriage should possess a combined friction and hydraulic brake, the rotation of the wheels being entirely suppressed.

It is not necessary to have all of the carriage wheels of the same weight. Those for the limber and caisson may be made lighter than the gun carriage wheels. The shifting of wheels will be a comparatively rare expedient, and always a temporary one. The weights should be as follows: 165 pounds for gun carriage wheels, and 143 pounds for all other wheels.

Ultimately it may be possible to use Mannessmann steel for spokes and felloes, and the spokes might be made hollow. Provisionally the spokes should be made of hickory and the felloes of acacia wood. Patent nave-boxes are to be used, with the Mannessmann device for taking off wheels quickly. The diameter of the wheel should be 4.5 feet with a tire of steel 2.75 inches wide. The axles should be of hollow Mannessmann steel, weight of gun carriage axle, 135 pounds, for all other axles, 80 pounds. Roller bearings are not considered necessary, as German experiments have shown that the friction on the nave is only 1% of the total load.

The limber is to have a tubular steel frame and pole, and a spring limber hook. The limber will be provided with one chest supported upon springs. The possibility of using springs in the interior of the chest is discussed, for Wille considers that the jostling hurtful to the carriage is due to the balloting of the ammunition in the chest.

The form of the ammunition will be such that it will be necessary to transport it in a horizontal position. This will insure a reduction in the height of the chest, a lowering of the center of gravity, and the cannoneers will be able to mount and dismount with greater facility. The chest will be made wide enough to accommodate four cannoneers seated back to back, and will be closed by a door swinging to the rear.

The limber is calculated to carry 30 rounds of ammunition, the caisson, 42. The caisson will be a trifle lighter than the piece. The piece will habitually have the cannoneers with it while the caisson is often abandoned to itself. Moreover, in emergencies, the carriage harness will be repaired at the expense of that of the caisson.

The author thinks that almost without exception artillery carriages are too heavy. He says :

"If upon trial a new carriage is not stressed to any marked degree, the chances are a thousand to one that many of its parts are too strong, and consequently too heavy."

"It is the general rule of service to determine and report upon the weak parts of a carriage with a view to reinforcement ; but we rarely hear of any systematic efforts to determine what parts are *too* strong with a view to a reduction of weight. Consequently the construction has generally been too heavy, for it would be a miracle if all the parts of the carriage were exactly of the requisite strength."

"In seeking an excess of strength and durability to guard against a possible accident that might happen to one piece in a thousand in an entire campaign, the result has been an unnecessary excess of weight. With this exaggerated prudence we carry upon the 999 other pieces a useless and hurtful weight, and the chances are that in the case of the thousandth, the breakage will occur in some part where reinforcement had never been considered necessary."

The General thinks that the forge wagon is an unnecessary encumbrance. He calls attention to the fact that in the War of 1870-71, the rôle of the forge was limited to the fitting of horse shoes, and to small work generally. In nearly every case, the greater part of the iron-mongery was turned in intact at the end of the campaign. He recommends that in lieu of the forge wagon, a small portable forge provided with a supply of small iron be transported upon one of the supply wagons.

The (then) German supply wagons were constructed on the same principle as the caissons. The actual weight of a supply wagon was 2275 pounds, and by economizing as suggested in the case of the wheels and axles of the caisson, this weight could be reduced to 2050 pounds. Taking 4450 pounds as the limit of the total weight, this arrangement would admit of a load of 2200 pounds.

With a view to the remodelling of the actual loads transported by the supply wagons, General Wille divides the articles carried into four categories, and disposes of them as follows :

1. Those that are generally useless and should be left behind.

2. Those that might be rarely in demand. These should be transported in the ammunition train.

3. Those that might be used by serveral batteries in common. These articles should be consolidated in a battalion or "group" wagon.

4. Those that are indispensable to the battery and should be transported in the battery wagons. Three wagons should be sufficient for this purpose ; or two, provided that the quantity of grain transported be reduced.

Captain H. A. Bethell, R. A., has calculated the following data for General Wille's "Gun of the Future" :

	1000 yards.	2000 yards.	3000 yards.
Remaining velocity, f.s.	2137	1750	1425
Angle of elevation	26½′	59′	1°40′
Slope of descent	1/105	1/39	1/19
Angle of opening of shrapnel	9°28′	10°20′	11°24′
Dept of zone of effective shrapnel bullets,—yards	765	726	602

CRITICISMS UPON GENERAL WILLE'S "GUN OF THE FUTURE."

The *Militar Wochenblatt* sonsiders the parallel drawn by Wille between the field gun of the future and the infantry small arm the fundamental defect of his project. In the case of the small arm, the ball is intended to disable one man only, and as long as this object is accomplished there is no objection to reduction of weight,—the flatter the trajectory, the more efficient is the weapon. With shrapnel fire however, the shrapnel is merely a vehicle whose function is to transport the balls to a point where they can perform the most efficient work. The *Wochenblatt* calls attention to the fact that a considerable curve in the trajectory is necessary for firing over firiendly troops, and that a flat trajectory is a fatal defect in a field gun.

A great many critics find fault with the high powder pressure necessitated by the velocity adopted by Wille. This pressure is estimated to be between 50,000 pounds and 65,000 per square inch. The highest gun rendement heretofore obtained has been

1000 foot pounds,—whereas the Wille gun calls for 1735 foot pounds.

A majority of the critics approve of a deep zone of shrapnel effect, a high velocity, flat trajectory, and high power. A minority object to a flat trajectory on the followihg grounds:

1. The danger of hitting one's own troops.

2. The enemy is safe when posted on the reverse slope of a hill.

3. Want of searching power against sheltered troops.

In reply to these objections, General Wille represents:—

1. There is practically no danger of striking one's own troops posted in front of the gun: At a range of 2000 yards the projectile will pass 10 feet above the ground at a distance of 100 yards from the gun. As for premature bursts, a few degrees will make but little difference in the damage done.

2. Shrapnel fire will be most effective when the trajectory is parallel to the reverse slope. At ordinary ranges the reverse slope is less than the angle of fall: therefore, the flatter the trajectory, the more efficient the fire.

3 The angle of fall for the lowest service velocities is about 6 degrees at 2000 yards. This is quite insufficient for searching intrenchments. Such work is the function of the torpedo shell.

The General does not deny that his gun may be ruptured by premature explosions, but he maintains that the gun will not burst explosively. Nickel-steel has successfully withstood premature bursts where ordinary gun steel has failed.

The subject of flat trajectory versus curved trajectory is one of the unsettled problems of the day. The critics are divided in opinion and it seems that the whole question will find its definite solution upon the field of battle only.

The critics generally prefer the interrupted screw breech mechanism to the falling vertical block. The former is approved of even when fixed ammunition is employed, as the tendency is to force the cartridge home, and not to "guillotine" it, as is the tendency in the case of the falling block.

The caliber adopted by Wille is criticised as being too small for a satisfactory interior organization of the shrapnel. Attention is called to the fact that with the enormous pressure existing in the bore, the walls of the projectile will have to be excessively thick to prevent "upsetting."

The weight of the projectile seems to meet with general approval. The advantages resulting from the use of tungsten balls are freely admitted, but the scheme is considered impracticable. Tungsten is a comparatively rare element, and the ores in which it is found are quite difficult to reduce. Considerations of expense aside, it would not be safe to adopt tungsten for shrapnel balls, unless the government taking such a step owned its mines, and had previously stored sufficient metal to meet the exigencies of war.

It has already been stated that Wille favors fixed ammunition, and that he expects a weight of 17.5 ounces for his cartridge case. Captain Moch points out that such a weight is not at present (1892) realizable. Admitting these figures however the battery would carry about 900 pounds of dead weight.

The consensus of opinion is in favor of separate loading, the powder charge to be put up in a metallic case. Metal is preferred because nitro powders keep better in metal than in silk or serge, and there is no danger from burning fragments. The author freely admits that experience alone will determine which method of loading is the better.

It is generally believed that the carriage is too light to withstand the recoil of the gun. The General computes that the average stress per pound of gun and carriage for existing types is 230 foot-pounds. He claims that by the use of a hydraulic brake the stress on the carriage is reduced 60%, and by the use of a nitro powder the stress is further reduced 15%. Applying these figures he finds that the stress on his carriage is about the same as exists with present field carriages.

General Wille states that he has been on the proving ground when a gun was fired whose energy of recoil was as great as that of his own gun. In these experiments the carriage was about of the same weight as his; and, although it possessed no hydraulic buffers, it successfully withstood the shock of firing.

Some writers favor a shield. Wille believes that the device would weigh at least 250 pounds, and that the cannoneers would be demoralized by its presence. He thinks that the shield would act as a screen to explode shrapnel, and maintains that the cannoneers will find their best protection in superiority of fire.

One writer thinks that the ammunition supply will be insufficient if rapid fire is to be used. General Wille positively states that a rapid fire field gun is an utter impossibility. Recoil could not be suppressed unless the power of the gun were contemptible. He believes that "ordinary fire" would not be exceeded in service, even if it were possible to fire more rapidly.

Captain Moch objects to have compressor brakes on the ground that their action is jerky, and the spokes are liable to be broken.

Wille replies that the nave brake is lighter than any tire brake, and that he has seen the nave brake thoroughly tested by Gruson and Krupp. The "drag-shoe" adopted in the British service is favored by several writers as a compromise.

A DISCUSSION OF THE ERRORS OF CYLINDRO-OGIVAL PROJECTILES.

Translated from the French of General Douny in *Revue de l'Armée Belge* of November-December, 1899.

By J. M. WILLIAMS, 1st Lieut., 7th Artillery.

(Continued).

2nd Group. Errors produced by irregularities of initial velocity. These irregularities are easily calculated from a series of initial velocities registered by electro-ballistic apparatus. Further on it will be seen that, instrumental errors eliminated, the mean variation (Δv) in initial velocity is :

$1^{m}.13$ for the 8^{e} steel gun.
$1^{m}.08$ " 9^{e} "
$1^{m}.35$ " 12^{e} " model 1862.

The regularity of the powder is obviously the principal factor of the regularity of the initial velocity; but it is also very important that the projectiles have absolutely the same position in the chamber at all shots. To effect this it is necessary that the slope of the cone of junction of bore and chamber be sufficiently abrupt to prevent considerable differences in position of the projectiles being caused by slight variations in diameter of the lead casings (or of the copper bands). Let us assume, for example, that the tangent of the angle made by an element of the cone of junction with its axis is 0.05 ; then a projectile whose band should have a diameter $0^{m}.0003$ smaller than the normal diameter of band, would be $0^{m}.003$ farther forward in the bore; thus the volume of the chamber could be increased from ½ of one per cent to one per cent, and this could produce a very considerable falling off in initial velocity.

It is evident that irregularities in the position of the rotating bands would produce similar results.

In order to show the importance of the variations in velocity caused by variations in the length of chamber, we shall have recourse to the data of appendix III.

The first column of the tables gives the distance from the base of the shell to the head of the breechblock ; the second column gives the corresponding initial velocity. By arranging the projectiles of each series of 20 or 21 shots in three groups according to the distance from base to head, we obtain the following results:

Series.	Mean initial velocity, the distance from base of projectile to head of block being:		
	480 to 482^{mm}	482 to 484^{mm}	482 to 486^{mm}
1 and 2	$351^m.6$	$349^m.5$	$348^m.5$
3 and 4	$351^m.5$	$350^m.4$	$349^m.8$
5 and 6	$351^m.1$	$350^m.1$	$349^m.9$
Mean	$351^m.3$	$349^m.9$	$349^m.4$

These figures, whose agreement leaves no doubt, show that a mean displacement of $0^m.004$ toward the muzzle, has produced a mean diminution in velocity of about $2^m.10$.

3rd Group. Errors caused by variations in the resistance of the air. These variations in resistance depend upon the projectile, that is to say upon its mass, its slope, and its position in the tangent to the trajectory, or else they depend upon the changes in density and in motion of the air itself. These disturbing causes can affect only the factors g', A, m, k and B, which enter the equations of the normal trajectory either directly, or indirectly through the constants k and B.

Variations in the mass and the form of the projectile can lead to only a constant increment or decrement in the term $k = \frac{A R^2}{m} v^2$

They are not important. In fact, the masses of the projectiles differ only by thousandths (after weighing), and a numerical test immediately proves that, in these limits, differences in mass are without effect. As much may be said of variations in shape, considering the method employed in manufacturing our shells. And finally it seems that it is also true for variations in diameter, the projectiles having to satisfy very strict requirements before acceptance, and the rotating band being accurately sized by the forcing into the grooves.

The variability of the position of the center of gravity introduces errors, whose investigation requires a brief summary of the method by which the equation of the trajectory has been determined.

The axis of a projectile fired from a rifle of right handed twist, swings about the tangent, its point remaining always to the right of the vertical plane containing the tangent. In any one of its positions let G (Fig. 4) be the center of gravity, and $G\,M$ the projection of the trajectory upon the plane of fire. The resistance of the air, supposed concentrated upon the point O, is resolved into three components:

1st. *O A*, a component in the direction of *G T*, the tangent to the projection of the trajectory upon the plane of fire.

2nd. *O I*, a vertical component.

3rd. A component perpendicular to the plane of fire.

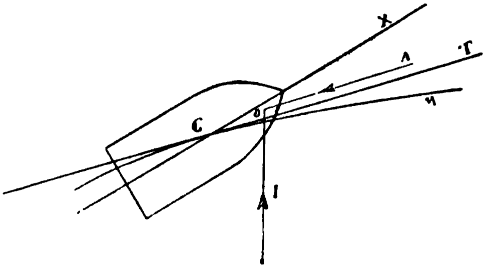

Fig. 4.

The component *O A* retards the translation along the tangent; its intensity evidently depends upon the inclination of the axis of symmetry, *GX*, to the tangent; the farther the axis departs from the tangent, the greater the effect of the air upon the projectile. This inclination varying incessantly because of the swinging of the axis about the tangent, the resistance of the air is also continually affected by it. But we know that we have obtained a sufficiently exact equation of the trajectory by giving to k, the coefficient of resistance, a constant mean value, slightly greater than that k' which would be the exact value corresponding to a projectile whose axis should always coincide with the tangent. We may write then:

$$k = k' + k'',$$

in which k'' is the mean increment of the coefficient of resistance due to the conical movement of the axis. If the center of gravity does not occupy the mean position upon the axis, the moment of the acting forces being different, the swinging of the axis will also be different; and then the coefficient of the tangential resistance will undergo an increase or a diminution according to the variation of k''.

But, in general, not only will the center of gravity be more or less distant from the head than is true in the mean or "average" case, but even will not lie upon the axis of symmetry. Moreover, while the projectile is travelling through the bore of the gun, its axis of symmetry will not coincide with the axis of rotation, nor will the center of gravity lie upon the latter axis. Under these conditions as soon as the projectile shall have left the muzzle, the center of gravity will describe a trajectory whose first element will not coincide with either the axis of symmetry, or the axis of rotation; there will then result an irregular rotation, and this will introduce other variations in the coefficient k'' and consequently in k, the coefficient of tangential resistance.

General Mayevski has calculated that for the Russian 4 *l* shell, which approximates to our 8^c shell,* the normal diminution of range caused by the increment k'' of the coefficient of resistance of the air due to the normal conical movement of the axis of symmetry, is only about 4 m. for the distance of 2650 m., which corresponds to a lowering of the center of impact by about $0^m.80$. Hence, at first sight, one would be tempted to believe that the errors introduced into that quantity by the irregularity of rotation of the projectile and by the irregularity of the position of its center of gravity, are negligible in comparison with other errors, experience proving that the total vertical error reaches $3^m.40$ at the distance considered.

But, in the first place, we may doubt whether the increase in resistance produced by the nornal swinging of the axis lowers the point of impact only $0^m.80$ at a distance of 2650 inches. We know indeed how experience discredits the result of calculations relative to the resistance offered by the air to the motion of curved surfaces. Mayevski was unable to take into account the resistance that the grooves made in the lead casing can offer to the passage of the air over the surface of the projectile; and this is a resistance that can be important when the position of the projectile is somewhat oblique to the direction of translation.

Then we must not forget that in its normal swinging, the axis of symmetry departs from the tangent by only a very small angular distance; it results from this that the angular errors in the position of this axis can aquire a very considerable relative importance, in other words that $\Delta k''$ can be an important fraction of k''.

These considerations prove that the errors which occur in the swinging of the axis of the projectile might lead to an error in the ordinate that would not be negligible, at least *a priori*.

The second of the components of the resistance of the air, acting along the vertical OI (fig. 4), results from the inclination of the axis of the projectile, either above or below the tangent. Above the tangent, the pressure of the air is stronger upon the under side of the projectile and tends to raise it; below the tangent, the pressure is stronger on the upper portion of the projectile and tends to lower it. We know that the sum of the raisings is greater than that of the lowerings; the difference, *h*, between the sums is the vertical deflection at the range considered.

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* And to our 3.2 inch shell.—Tr.

In order to take account of the vertical deflection upwards, we substitute, in the equation of the vertical projection of the trajectory, for the sometimes ascending and sometimes descending pressure that produces it, a constantly ascending vertical force mg'', which is to be of such a value as to produce at great ranges an upward deflection of the projectile equal to the difference *h*. This is equivalent to diminishing the weight of the projectile by mg''; that weight thus becomes in the equation $mg - mg'' = mg'$.

General Mayevski has determined the limits within which the action of the force mg'' is observed, and numerical tests have led him entirely to neglect this term in the equation of the trajectory, so unimportant are its effects; under its influence the Russian 4 *l* shell fired with a velocity of 305 m. would rise less than 1^{m} over a range of 2650 m. Here practical experience has confirmed the theoretical deduction; it has shown that the vertical deflection is so small as to escape observation.*

The vertical deflection itself being little known, it is naturally impossible to determine the value of errors caused in it by the irregular swinging of the axis of the projectile about the tangent. We may, however, remark that these errors must be nearly proportional to those which arise from the same cause in the horizontal diviation and which will be discussed further on.

There remain for discussion the perturbations caused by the atmosphere itself.

The variations of the density of the air resulting from changes of pressure, of temperature, and of hygrometric state that occur during the firing, produce a corresponding increase or diminution of *k*; they are evidently without appreciable influence between two consecutive shots, but become very important if the firing be long continued. In fact, as a result of information furnished by the Observatory, it is established that during summer, within ten to fifteen hours, there is ordinarily:

A barometric variation of $\pm 4^{mm}$
A thermometric variation of $+ 9^{\circ}$
A hygrometric variation of — 10%.

These changes often correspond to a diminution of density nearly as high as 4%. Since the value of *k* undergoes the same change, the shots rise higher and higher on the target, and we find a progressive departure from the center of impact. In actual service firing we could meet this condition by changing the elevation; but in experimental firing for the purpose of determining the mean error, the elevation is to remain invariable, and it is easy to see that there result irregularities corresponding to the other accidental variations.

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* See our "Etude de la trajectoire des projectiles oblongs."

Let us assume that the shots follow at regular intervals, and that the density of the air regularly decreases from the beginning to the end of the firing, decreasing in all as much as 4% ; then the center of impact will correspond to a discrease of 2% and the mean of the resultant errors to a difference of density (or of *k*) of 1%.

It is evident that this variation of the density of the air leads also to a disturbance in the conical movement of the projectile, and consequently to a change in the horizontal and in the vertical deflections; but at a rate of 1% this error is evidently without effect in the presence of the other errors.

The action of the wind is very important.

The wind always blows nearly horizontally—at least over level ground. Besides, we may consider it as constant throughout the time of flight. Undoubtedly this is not true near the ground; but in the upper regions of the atmosphere, where the projectile is during the greater part of its flight, it may be established as a fact by the observation of small balloons; ordinarily these rise rather irregularly till reaching a certain height, then they take a direction and a velocity that change very slowly.

When the air has a movement of its own, its molecules are met by the projectile with a velocity that is the resultant of the velocity of the wind and of the velocity of the projectile. Let us assume, for the sake of simplicity, that the resistances which act upon each of the elements of the projectile's surface have a single resultant; we then see that the intensity of this resultant, its direction, and its points of application are modified by the wind, and that the trajectory, as well as the conical movement of the axis about the tangent, is accordingly changed.

However, in view of the small value of the velocity of the wind compared with the velocity of the projectile, and in view of the great moment of inertia of the projectile's mass about its axis the conical moment can be affected to only a very small extent. This conical movement is in fact controlled, more than by anything else, by the continued change in the inclination to the horizontal of the tangent to the trajectory; and whatever be the velocity and the direction of the wind, the tangential component of the resistance will always have the preponderating influence. Now, we shall see later that this resistance varies only by a few hundredths under the influence of an ordinary wind; hence the wind can change but very slightly the conical movement of the projectile's axis of rotation.

If this slight change in the conical movement were alone concerned, it would be sufficient, in taking account of it, to substitute for k in the formulas

$$k + \Delta k, \text{ for } g', g' + \Delta g', \text{ and for } B, B + \Delta B.$$

But it is also and especially necessary to take account of the alterations made in the trajectory by the change in intensity and in direction of the resistance of the air, not considering this time the variation of the conical movement. Under this influence the coefficients $k + \Delta k$, $g' + \Delta g'$, and $B + \Delta B$ are to undergo new changes: but to get values for these changes it will be sufficient to consider the original coefficients k, g' and B, for we shall thus neglect only second differences.

To pursue the question further, let us examine first the effects of a wind blowing horizontally in a few particular directions.

A. *Wind blowing from the target to the piece.*

1st. In the first place there will be an increase in the tangential resistance. In order to find out approximately its importance, we may admit that this resistance

$$\rho = C k u^4$$

will become

$$\rho = C k (u + \omega \cos \theta)^4$$

ω representing the velocity of the wind.

From which we get

$$\rho = C k u^4 \left(1 + \frac{\omega \cos \theta}{u}\right)^4 = C k u^4 \left(1 + \frac{4 \omega \cos \theta}{u}\right)$$

in view of the small value of $\frac{\omega}{u}$.

Then we should have to substitute in the calculations the variable factor $k\left(1 + \frac{4 \omega \cos \theta}{u}\right)$ for the constant factor k; but in that case the culculations would become involved. Therefore in applying the formula we shall substitute for the ratio $\frac{4 \omega \cos \theta}{u}$ a mean value.

Thus, to take a case, if it were a question of finding the effect of a wind blowing with a velocity of 2^m from the target toward the piece, the resistance upon the 8^c shell would be calculated by substituting for k

k (1.027) for a range of 2000 m.
k (1.029) " " 2500 m.
k (1.030) " " 3000 m.
k (1.031) " " 3500 m.

We see that for ordinary and for long ranges the increment, due to wind, of the coefficient of the resistance of the air, varies but slightly with the range. Furthermore, it can be established that the variations of this coefficient have no influence upon the accuracy of fire except at ordinary and at long ranges. Therefore we may, without appreciable error, make use of a constant increment of k in calculating the deflection caused by a constant wind.

The greater the sectional density of the projectile and the higher its muzzle velocity, the more, as we shall see later, is the effect of the variation of the resistance of the air confined to long ranges, that is to say to a limited portion of the trajectory; under such circumstances the observations just made are still more convincing.

2nd. The vertical deflection will be changed because the resistance of the air has changed direction. In the ascending branch of the trajectory the pressure of the air upon the under side of the projectile is the stronger, and consequently tends to push the projectile up; in the descending branch the pressure on the upper side being stronger tends to push the projectile down. Hence, there is counter-action, and the vertical deflection will be but slightly affected; all the more is this true since, becauce of the flatness of the trajectory, the differences of pressure in question are not only very small at the beginning and at the end of the flight, but almost without effect during it.

3rd. The lateral deflection will be increased, in proportions analagous to the tangential resistance, by reason of the increase of the total resistance.

B. *Wind blowing from piece toward target.*

The modefications are similar to those we have just analysed.

C. *Wind blowing, horizontally, from left to right.*

If it is borne in mind that the projectile always has its point to the right of the plane of fire, it is easily seen that the resistance of the air is increased: first, because the striking velocity of the air is the resultant of the velocity of the projectile and of the velocity of the wind; second, because the air, coming more from the left, is met more obliquely by the projectile.

Considering the direction of the axis along which we have resolved the resistance into components, we shall state further:

1st. That the tangential resistance is also increased, provided the angle that it forms with the total resistance is so small that the tangential resistance is practically equal to the total resistance.

2nd. That the vertical deflection is not changed.

3rd. That the component perpendicular to the plane of fire increases in very considerable proportions—less because the total resistance has increased than because the least variation in its direction is shown by very great changes in that component.

D. *Wind blowing, horizontally, from right to left.*

In this case the direction of the total resistance approximates more closely to the direction of the axis of the projectile; it may, at times, coincide with it and even pass it, coming from its right. Hence there results:

1st. A diminution in the tangential resistance (unless the wind be very strong) since the projectile meets the resistance of the air less obliquely.

2nd. No change in the vertical deflection.

3rd. A considerable change in the component perpendicular to the plane of fire, which may become ineffective or even be directed from right to left; that is to say it may counteract the drift or even produce deviation to the left.

Let us incidentally remark that, contrary to a frequently expressed opinion, the wind blowing perpendicular to the line of fire changes the vertical projection of the trajectory. If the wind comes from the left, it diminishes the range; if from the right, it increases the range—at least in certain limits; the maximum range is attained when the drift is exactly nullified.

If now we consider the most general case, that in which the wind blows in any horizontal direction whatever, the effects that we have just analyzed will be combined and will be manifested thus:

1. By a variation in the tangential resistance that we may represent in the calculations by a variation of k.

2. By a variation of the coefficient of lateral deviation B; this variation may be very important, even changing the sign of the coefficient.

3. By an unimportant variation in the vertical deflection, which we allow for by changing g'.

We have not here to concern ourselves with the effect of a wind that remains constant during the continuance of the firing, since it would result in only a constant deviation. But it is otherwise when, as always happens in rare cases, the wind undergoes gradual changes, increasing, decreasing or changing direction. In this case the center of impact changes little by little and there result errors similar to the accidental errors.

According to the information given out from the royal observatory, the velocity of the wind is nearly always greater in the afternoon than in the morning; the difference is from 1 to 2 metres in winter and from 2 to 3 metres in summer.

Let us assume that the wind, without effect at the beginning of the firing, increases about the middle, blowing from the targe toward the piece with a velocity of 3 metres.

According to the calculations above, the coefficient k will be increased by about 0.045 of its value for the second half of the shots. The mean error of k, from this cause alone, would then read 0.0225 of the value of that coefficient. We see, then, that if the firing is long continued, the mean errors obtained will be much larger, unless in proceeding with the calculations we sift the data.

Before closing the discussion of the causes of error, it is necessary to bring out an important difference in their natures. Some are *intrinsic*, i. e. they depend upon only the system of gun and the class of carriage; others are *extrinsic* and depend upon the circumstances of fire: the greater or less skill of the personnel, the state of the soil, the changes of the atmosphere.

Must we endeavor to determine the probable errors due to the intrinsic causes alone, or must we try to find the errors due to the intrinsic and the extrinsic causes combined?

In theory it would be possible to determine each of the kinds of error. It would suffice, in obtaining the first, to place the piece upon a well laid platform and to consider only shots fired while there was no wind; then to group the result of each practice in such a way as to abstract the variation in the air's density, or else to correct the shots by allowing for that variation.

On the other hand, in order to obtain the probable error due the intrinsic and extrinsic causes combined, it would be necessary to combine results of firings executed under varying conditions of personnel, of soil, and of atmosphere; and that too in sufficiently large number for the result of the observations to be considered as due to mean conditions. The firings would have also to be of a mean duration, in order to allow for the mean atmospheric change during one firing.

The error due to the intrinsic causes alone, is evidently the more interesting. In the first place it is the only one to be considered when we are testing a system of cannon and then it is the only one that can be determined with any certainty, for it is very difficult to collect data due to mean conditions of personnel, of soil, and of materiel.

Finally the intrinsic error is found to differ, much less than we could believe at first sight, from the error obtained from any one practice. Indeed, if in the course of the practice, the density of the air materially changes, or if the wind increases or decreases, we are made aware of it by the moving of the center of impact; a correction in the setting of the sight can bring it back to the desired place, and in this case, the probable error will be in part freed from the extrinsic causes of error.

It must be added that it will always be impossible to estimate how far the present conditions of personnel, of soil, and of atmosphere differ from the mean, and to calculate the difference that exists for this reason between the probable error of the present practice and the probable error obtained under mean conditions, the knowledge of the latter, then, presents no practical advantages.

In practice, this distinction between the methods of finding the probable error can almost never be made, for the data are not sufficient to permit us to select. More often we shall have to consider all, discarding only the data of absolutely abnormal conditions, such as having used a different kind of powder or a different kind of carriage.

(To be continued).

NOTES ON RAPID-FIRE FIELD ARTILLERY.

TRANSLATED FROM THE FRENCH BY CAPT. W. W. GIBSON,
ORDNANCE DEPARTMENT, U. S. ARMY.

NOTES ON THE CONSTRUCTION OF ORDNANCE.
Washington, April 1, 1901.

I.—BELGIAN COMPETITIVE TRIALS FOR THE CHOICE OF A RAPID-FIRE FIELD GUN.

[Extract from the Review of the Belgian Army, Volume 4,
Twenty-fourth Year, January-February, 1900.]

The papers have recently announced the completion of the competitive trials of rapid-fire field guns in Belgium and the success of the Nordenfeldt-Cockerill material.

This information can not fail to please those who are interested in the improvement of the armament of our army and in the success of our national industries.

The replacement of old types of small arms by others of rapid-fire type and longer range, inevitably necessitated a change in the armament of artillery.

Certain countries, such as France and Germany, have already undertaken the transformation of their field artillery. England also has entered on this path, but on a very small scale, as she does in everything which relates to her land forces. Other countries hesitated a moment on account of the great expense involued, but are now endeavoring to make up for lost time, and are actively pushing their investigations. Almost all have invited competitive trials for the choice of a rapid-fire field gun, particularly Spain, Italy, Norway, Roumania, Russia, Sweden, Switzerland, and Belgium. A few, and they are the smaller number, follow the solution of the problem in their own establishments, or have sent commissions to foreign manufacturing establishments.

Belgium contented itself for several years in closely following the movement, and in experimenting with field material from the Nordenfelt Company of Paris, which had been submitted to it by the John Cockerill Company of Seraing.

It was thus that the school of practice at Brasschaet, in 1896, came to try a gun with central breech screw, mounted on a carriage with recoil features and with a hydraulic brake and wheel brake combined.

This piece carried a shield.

Weight of projectile = 5.850 kilograms = 11.9 pounds.

Initial velocity = 480 m. s. = 1574.9 f s.

The following year a new model by the same constructors was tried. The breech mechanism consisted of an eccentric breech screw ; the carriage, similar to the preceding, was improved as a whole and in its details.

A clamping device provided for the securing of the recoil slide to the carriage body in case the hydraulic brake was put out of action.

Weight of projectile = 6.250 kilograms = 13.78 pounds.

Initial velocity = 500 m. s. = 1640.5 f. s.

As is seen, the weight and velocity of the projectile, and in consequence the ballistic power, continued to increase. It is true, however, that the longer gun measured 33 calibers in length while the model 1896 measured only 30.

None of these systems entirely satisfied our artillery service ; but the Government finding the question sufficiently matured, opened a competitive trial to which all foreign manufacturers were invited.

One condition, however, was imposed : the material was to be tried in Belgium, and in case of success to be entirely constructed in that country.

Three other competitors appeared at the competition ; for proper reasons we do not give their names. It is sufficient to say, that all presented material of the first quality, and the struggle was of the liveliest nature. All the guns were uniformly of 75 mm. (2.95 inches) caliber, and the projectiles 6.5 kilograms (14.33 pounds) in weight. At first only carriages with recoil features were presented.

That by the Cockerill and Nordenfelt companies had a trail spade and short recoil of the piece on the carriage.

Weight of projectile = 6.5 kilograms = 14.33 pounds.

Initial velocity = 500 m. s. = 1640.5 f. s.

The reduced dimensions of the trail spade gave it quite a different character from that of the trail spades usually employed. The only object of the spade was to get sufficient hold on the ground to permit the slide carrying the gun to recoil, and put the hydraulic brake in operation. The wheel shoes do the rest.

It is known that in case of other trail spades, penetration of the soil is first required ; lacking which, the hydraulic brake does not operate.

It was, moreover, the constant aim of the Nordenfelt Company to do without spades, as an essential part of its constructions.

It can not be denied that at first sight the systems with long recoil of gun on carriage and with the trail spade were the most attractive, because of their greater stability upon ordinary ground. With them the fixed material of fortifications is approximately attained provided the trail spade is held in the ground.

So the preferences of the commission were decidedly in favor of this system, when the Cockerill Company presented its rigid carriage with neither trail spade nor hydraulic brake.

It should be observed from this time that these two companies, which had used only ballistite powder, made use of nitrocellulose powder like their competitors, because of the decided preference manifested by our artillery for this kind of powder. At the same time they raised the initial velocity of the projectile from 500 to 525 m. s. = 1640.5 to 1721.53 f. s.

The mode of action of this material differs in all respects from that of the material with hydraulic brake and large trail spade; while the former aims at the minimum displacement of the carriage, in the latter the gun recoils very nearly a meter on the carriage on ordinary ground, returning immediately to its primitive position; a true motion of going and coming.

In soft soil, sand, or ploughed ground the recoil is much less. It is needless to remark that the commission was necessarily astonished at first at this novel behavior, but its surprise was so much greater when it can be stated that not only did the Corkerill carriage behave well under all conditions, but the rapidity of fire equalled that of the most stable mount, that is to say, 14 shots a minute.

What is the use, then, of complicating the construction by hydraulic brakes, by spades more or less rigid but deep, whose proper working, doubtful in light or soft ground, requires in hard ground a lodging prepared in advance. And hard grounds are just as numerous as soft; for example, tamped soil, paved or stony roads, country roads, footpaths, frozen winter soil. The more securely the spade is anchored in the soil the greater the stability of the system becomes and the more rapid the fire against a fixed target. But when the target moves across to the line of fire, and the correction in pointing in direction exceeds the lateral displacement of the gun on the carriage, the advantage disappears and gives place to serious drawbacks.

Besides all this difficulty the putting of the hydraulic or hydropneumatic brakes out of action will cause that of the entire piece, while with the rigid carriage deprived of its brake, the piece will continue firing without any disadvantage other than recoiling freely like the old models still in service.

To which of the two systems should the preference be given: to the less stable one, but one independent of the character of ground, or to the other, dependent on that, but almost immovable? The question merited an exhaustive examination.

We are ignorant of the precise conclusions of the commission; but it is to be presumed that it required a further series of trials, for a new commission was named, presided over by the director general of artillery. It had for members the president of the first commission, a colonel of the active army, and the chiefs of our three construction establishments—the arsenal of construction, the pyrotechnic school, and the royal gun foundry.

The series of tests ordered by the first commission comprised experiments in marching, a safety test at high interior pressure, a ballistic test for the determination of the charge, and tests for rapidity and accuracy at 1,500, 3,000, and 4,500 meters on different kinds of ground.

The trials of the second commission had for the principal object the comparative study of the systems with recoil-checking devices and the rigid systems under the ordinary conditions of war.

Trials with the gun on sloping ground and on paved streets and rapid firings against movable targets or with changes of targets were insisted upon. From what we have been able to learn, for nothing official has transpired, the trial was decisive. Only the rigid carriage permits the movements of an object crossing the field of fire to be followed without interruption and of passing rapidly from one objective to the other, which it was impossible to do with the carriage having a trail spade.

As to the Nordenfelt mechanism with eccentric screw, we believe it can be safely asserted that it was not subject to any criticism.

It was poved that neither dust nor rain would interfere with its satisfactory working.

A cartridge case split in the course of the experiments without interrupting the firing.

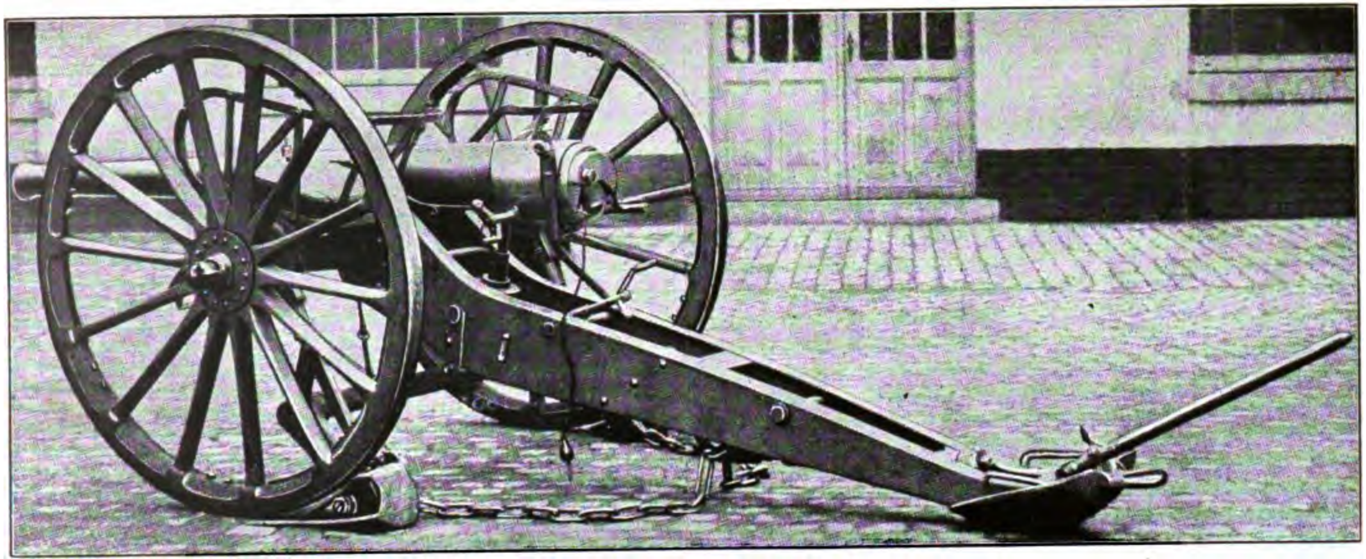
During all these trials the pieces were manned by the personnel from the batteries in garrison at the Brasschaet proving ground.

In consequence of the conclusions of the commission the Cockerill Company started the manufacture of a battery of 6 pieces and 3 caissons for the Belgian Government, which, it is said, will be ready next September.

PLATE I.

ARTILLERY MATERIAL

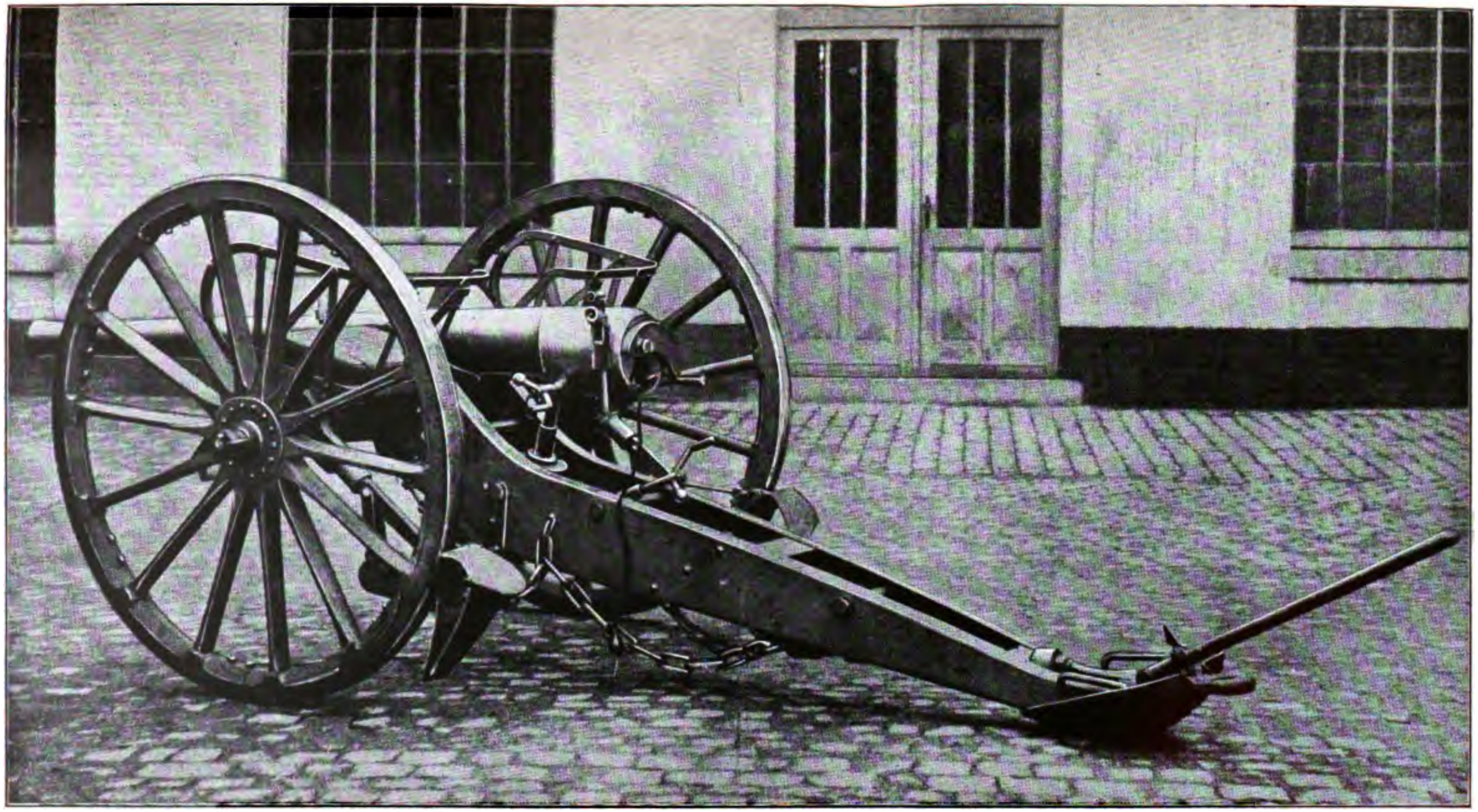
Constructed by the John Cockerill Joint Stock Company,
Nordenfelt Company's System, Paris.



75-mm. Rapid-fire Field Gun on Rigid Carriage, Model 1899, with Axle Seats. Firing Position.

Constructed by the John Cockerill Joint Stock Company,
Nordenfelt Company's System, Paris.

PLATE II.

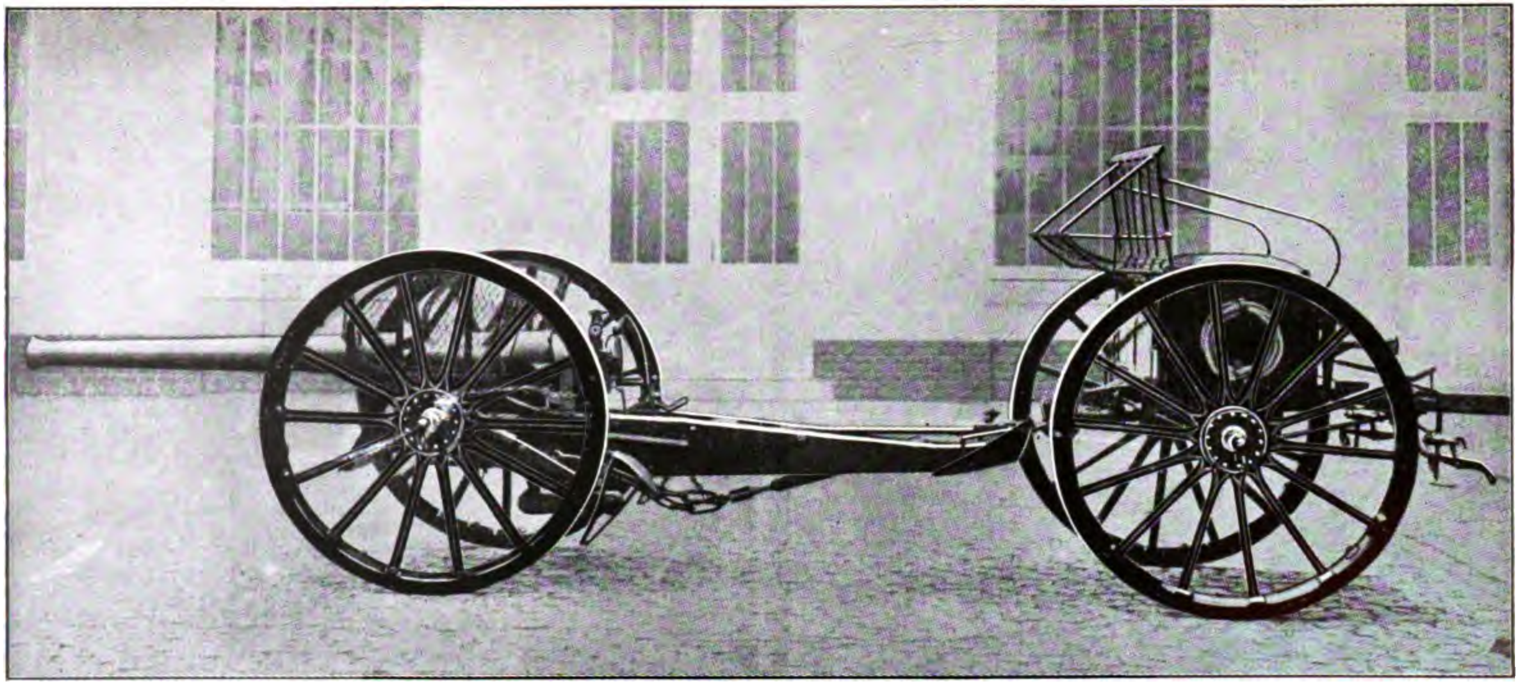


75-mm. Rapid-fire Field Gun on Rigid Carriage, Model 1899, with Axle Seats. Wheel Brakes Raised.

PLATE III.

ARTILLERY MATERIAL

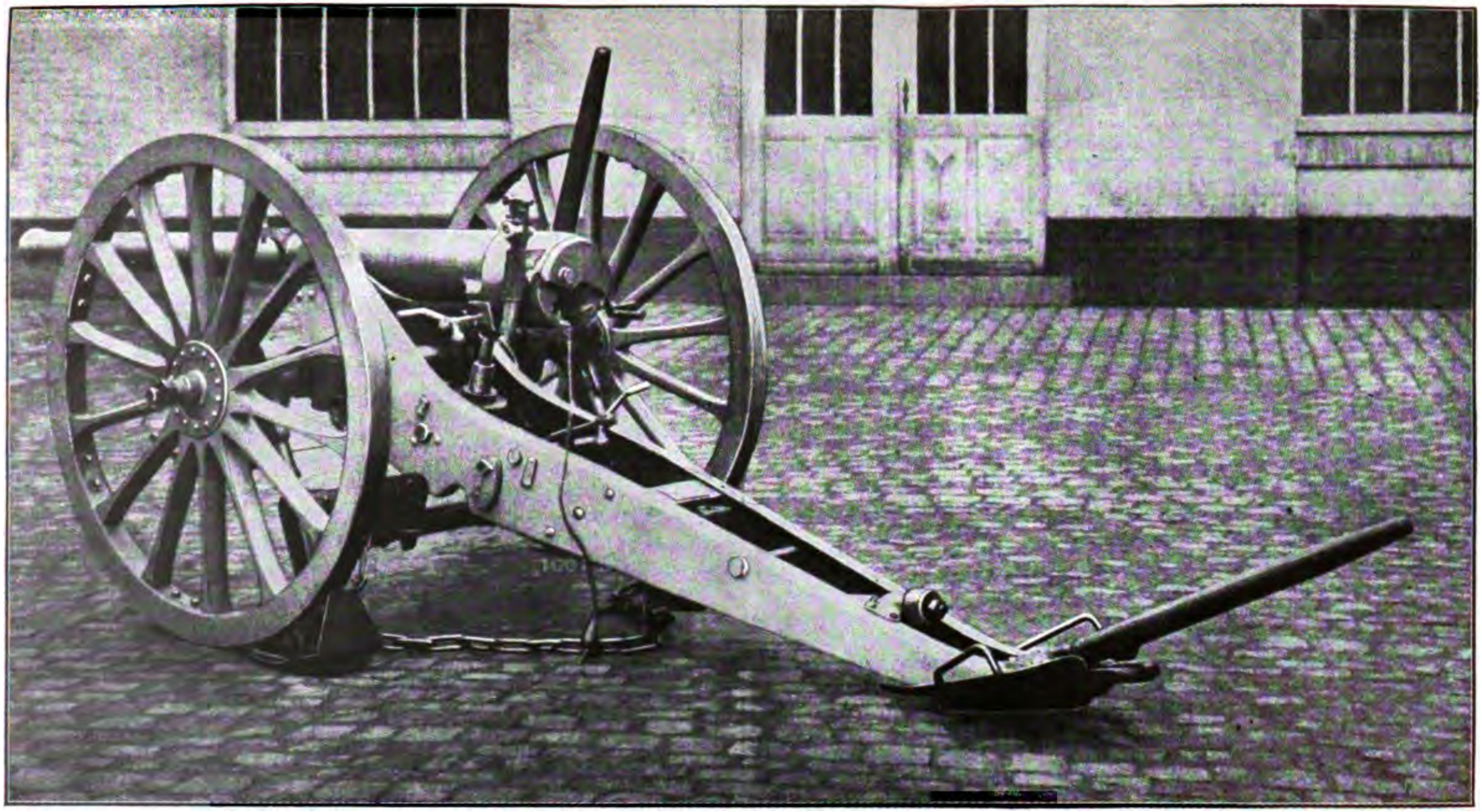
Constructed by the John Cockerill Joint Stock Company,
Nordenfelt Company's System, Paris.



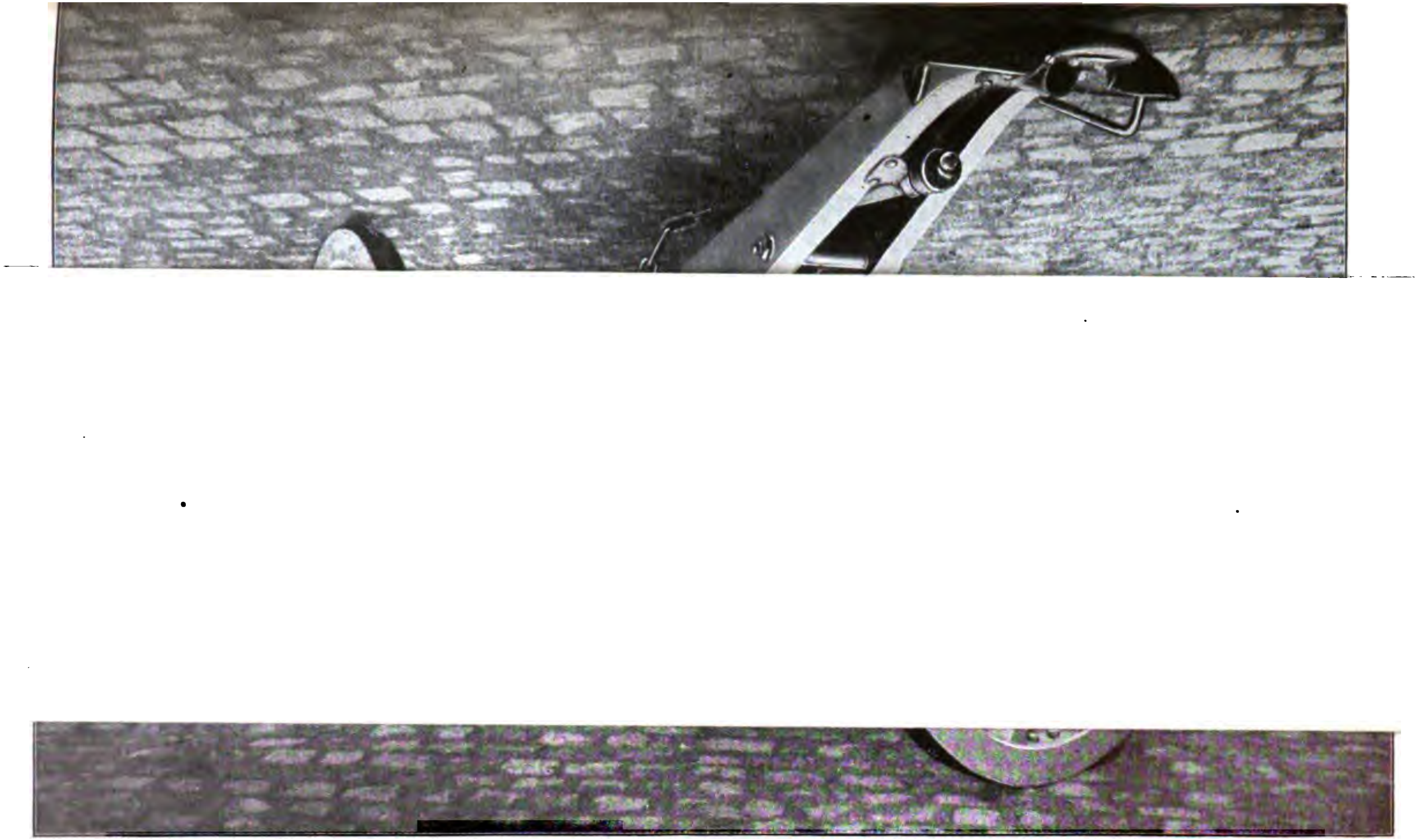
75-mm. Rapid-fire Field Gun, on Rigid Carriage, Model 1899, with Limber.

Constructed by the John Cockerill Joint Stock Company,
Nordenfelt Company's System, Paris.

145-4

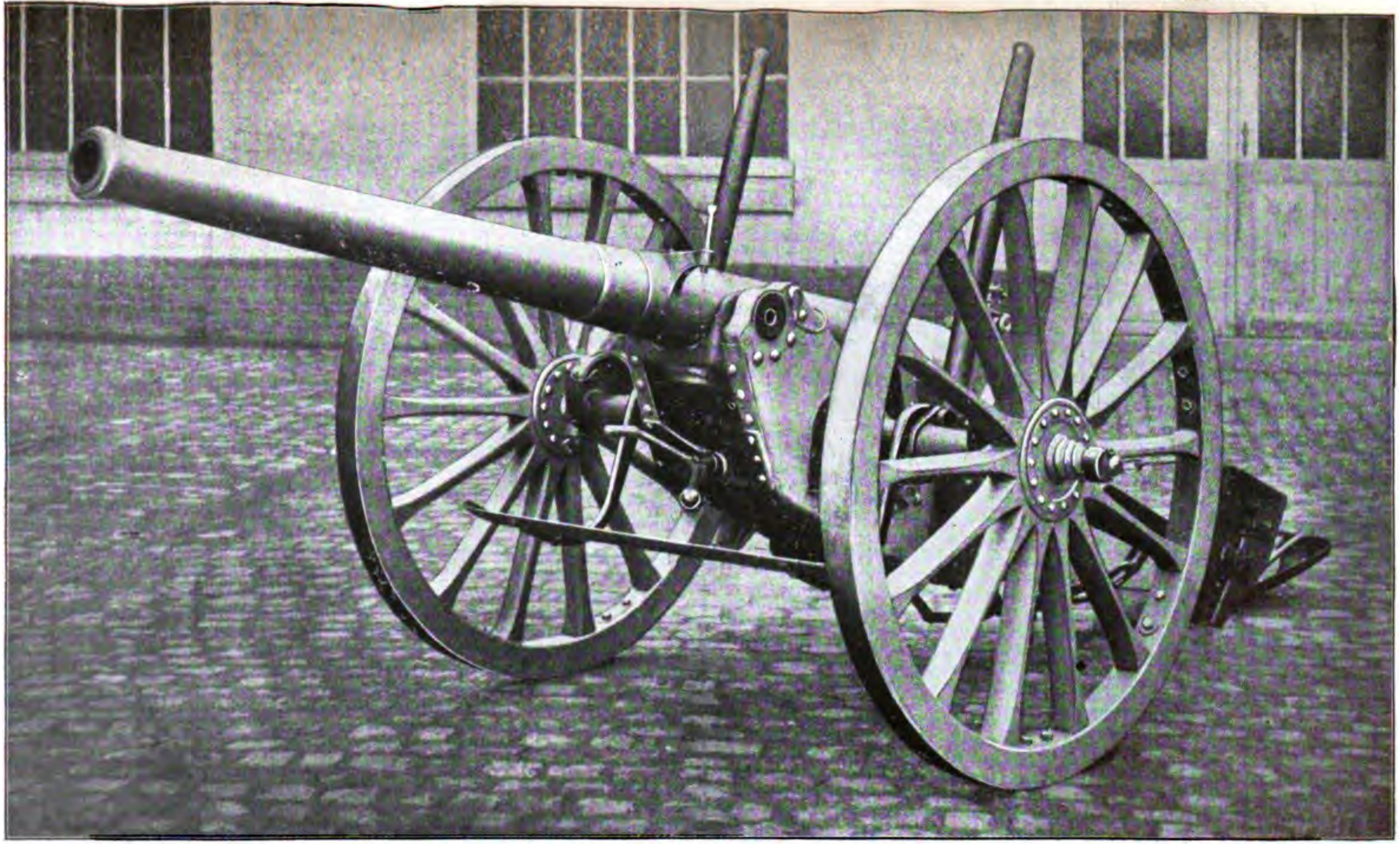


75-mm. Rapid-fire Field Gun on Rigid Carriage, Model 1899, with Footboard for Cannoneers Standing.



75-mm. Rapid-fire Field Gun on Rigid Carriage, Model 1899. with Brakes Raised. View of Footboard for Cannoneers Standing.

PLATE VI.



75-mm. Rapid-fire Field Gun on Rigid Carriage, Model 1899. with Brakes Raised. View of Footboard for Cannoneers Standing.

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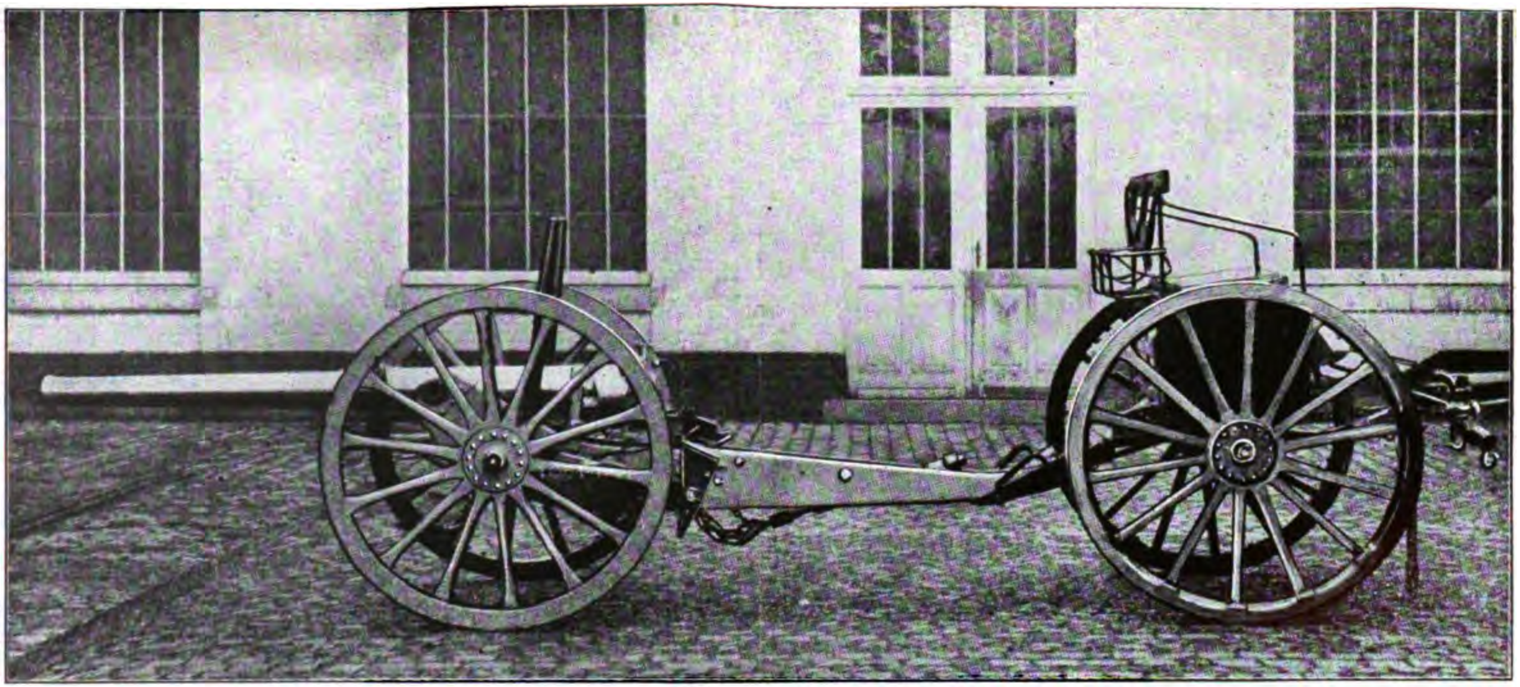
PLATE VII.

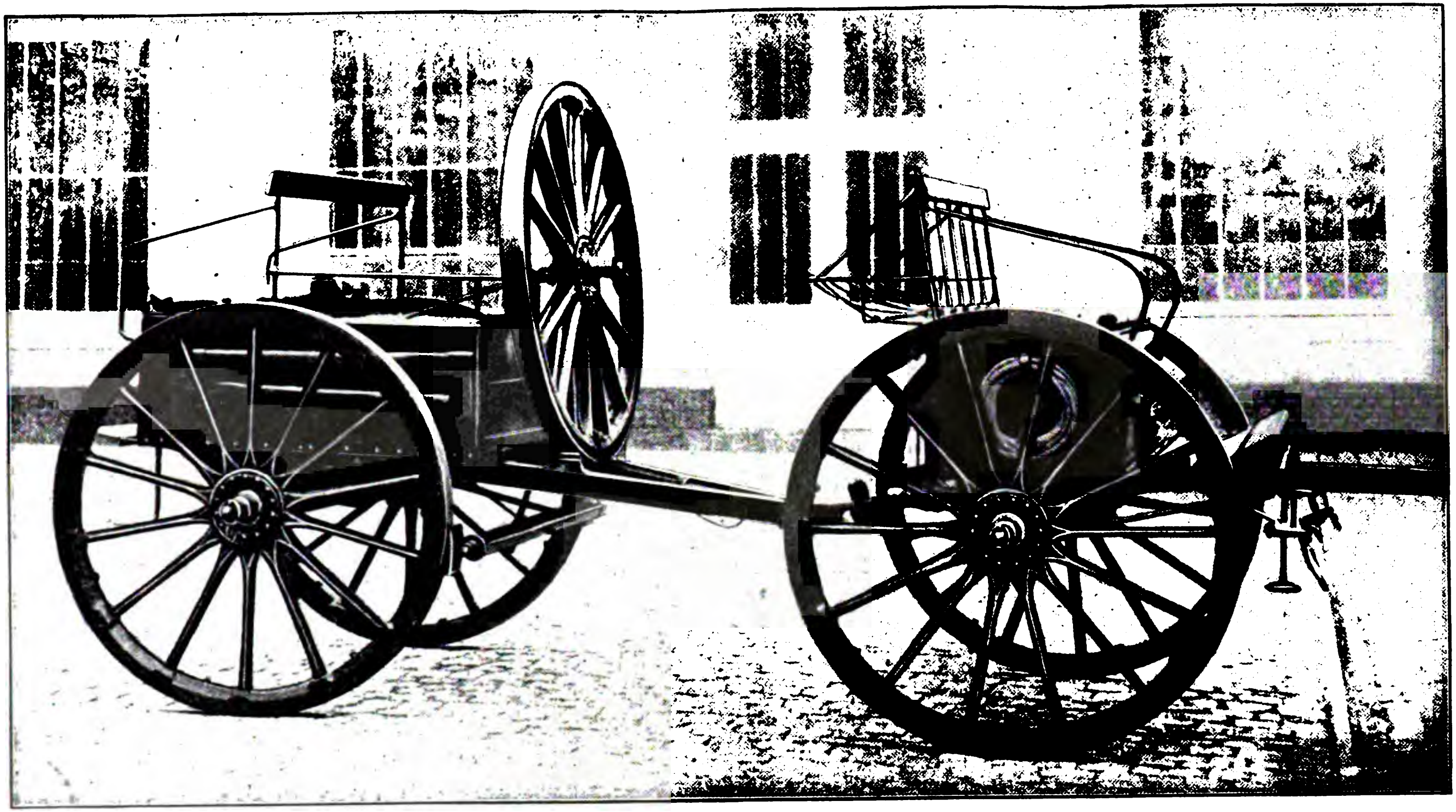
ARTILLERY MATERIAL
Constructed by the John Cockerill Joint Stock Company,
Nordenfelt Company's System, Paris.



75-mm. Rapid-fire Field Gun on Rigid Carriage, Model 1899, with Limber.

PLATE VIII.

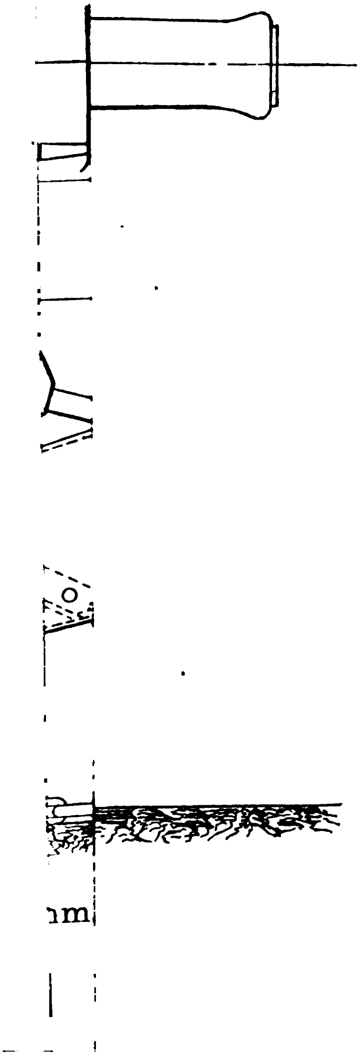
ARTILLERY MATERIAL
Constructed by the John Cockerill Joint Stock Company,
Nordenfelt Company's System, Paris.



Caisson Complete for 75-mm. Rapid-fire Field Gun, Model 1899.

HE BELGIAN ARMY.

ATE IX.



It is far from our intention to judge either one of the systems presented for competition, inasmuch as we have not seen them working.

It is also far from our intention to wish to strengthen our arguments by the reasons influencing the commission, for we do not know them. But we can examine the question from the point of view of the qualities required for good field material, and see if the solution found is justifiable.

Good field material ought to fulfill the following conditions: Lightness, simplicity, solidity, safety, accuracy, rapidity of fire, and facility of handling on all sorts of ground.

Lightness, accuracy, and safety being conditions sine qua non demanded of all systems, it seems useless to dwell on those points.

Solidity and simplicity afford guarantees for long use of. the material and decidedly constitute one of the most valuable advantages of rigid carriages.

For carriages with recoiling arrangements, stability on the ground being obtained only at the price of multiplied and complicated parts, it can be said that the one which possessed the quality of stability to the highest degree would be also the most liable to premature deteoration.

It is not sufficient for material to successfully stand the necessarily limited trials in a competitive test, it ought at all times to be ready for action. We know the fate in war time of mechanical arms which require for their care skilled workmen difficult to recruit among soldiers and which are always going to pieces. When we come to consider that our material, strong as it is already, requires so much repairing, what guarantee would systems of great mechanical complication give?

Who dares to claim that they will be at all times ready to stand the tests of actual warfare? Experiments on the proving ground have shown that the rapidity of fire of the rigid carriage permits on the average 10 to 12 shots a minute with exact aiming, and that the change of objective and the following of a movable target in the field is easier than with systems having recoiling parts.

To favor a greater rapidity is to fall into a dangerous error. Admitting that it may be useful in some extraordinarily rare cases to pour into the enemy 15 to 20 shots a minute, it should not be with such exceptional circumstances in view that material ought to be constructed, and at the price of such undoubted faults. Much has been said of the new French field artillery material, but up to the present time no one can boast of having seen it, and it seems thus far to have undergone only proving-ground trials.

It is impossible to estimate the importance of the qualities attributed to it until it has been issued and tried in actual service, and until our neighbors have been able to form a definite opinion in this matter and made it known.

Meanwhile the Cockerill Company has constructed for a foreign nation, according to the plans of the Nordenfelt Company, a system with a trail spade, and simple hydraulic brake located between the flasks.

This material, belonging to the category of stable systems, having been subjected at Seraing to numerous firing and marching tests, the Cockerill Company offered to submit it for trial on the Brasschaet proving ground. But the committee having decided against systems with trail spades, the project was abandoned. The material which successfully passed the competition presents a certain peculiarity. This is regarding the wheels.

In Belgium the old style wheels were adhered to—larger than those which it was the tendency to adopt in most countries, because of the principle that a large diameter facilitates traction and the passage of obstacles. But can it be concluded from this that a smaller diameter would not be satisfactory? The opinions of foreign countries are divided, and it is not our province to discuss them. Nevertheless, the fact remains that the Cockerill and Nordenfelt companies possess two types of field artillery material with rigid carriages, one with large wheels, Belgian diameter, and one with smaller wheels, that it brings out in other countries.

BRIEF DESCRIPTION OF MATERIAL.

We will confine ourselves to giving here a very brief description of the material that is occupying our attention. The Review of the Belgian Army has kept its readers in the last few years posted on the constructions and the progress made by the cooperation of the Nordenfelt Company of Paris and the John Cockerill Company of Seraing, of which detailed descriptions have been given in numerous articles to which it will be sufficient to refer our readers. The plates that are added to the present article, and which are mentioned hereafter, as well as the details and tables which follow, will give a sufficiently clear idea of the new rapid-fire field artillery material adopted for the Belgian artillery.

Plate I.—Gun with axle seats, brakes turned down ready for firing. View taken from the side of the gunner.
Plate II.—Same view, the wheel brakes raised up.
Plate III.—View of the piece attached to the limber. Ready to march.
Plate IV.—Gun with footboard and levers for cannoneers, standing up; one of the levers is placed on the trail for pointing; the piece is in the firing position. (Brakes let down.)
Plate V.—View of the gun with footboard, the two levers and the brakes in the marching position.
Plate VI.—View showing the footboard for cannoneers standing.
Plate VII.—Gun with footboard, limbered up.
Plate VIII.—View of caisson with its limber.
Plate IX.—Drawing of gun and its carriage (fig. 1). Design of breechblock; section through the axis and rear view (figs. 2 and 3).

GUN.

The gun of nickel steel is formed of a tube and jacket.

The line of sight is on the left side. The sight has a leveling devibe for pointing in elevation. It is provided with two motions, one quick for large corrections and the other slower, serves for slight corrections.

BREECH MECHANISM.

We will give only the main features of the breech mechanism, the detailed description having already been given in this review.

It is a cylindrical screw whose threads are interrupted over only a small part of the surface, which gives it great strength. The axis of the movement is below the axis of the piece, whence the name, eccentric screw. The whole apparatus for firing, firing pin, trigger, cocking device, lanyard, are mounted on the hand lever by which the screw is operated. A simple running button fastens the lever to the screw and permits the latter to be disengaged with the greatest facility. A very strong extractor is seated in the breech between the latter and the screw.

No part except the maneuvering lever projects whether the breech is opened or closed. The firing pin is never cocked except when the lanyard is pulled to discharge the piece. This allows the gunner, in case of missfire, to strike the primer as many times as may be necessary without anyone having to approach the breech.

The piece can be maneuvered at all gaits while loaded, from which fact it is possible to begin firing at the moment of coming into position.

To prevent accidental firing during maneuvering by shock, which is a very improbable thing, the cocking lever is locked by the aid of the lanyard pin, as shown in the sketch (Plate IX, fig 1).

Besides this, the apparatus is fitted with a special mechanism to provide against premature discharges by means of a safety notch, which prevents firing before the complete closing of the breech, and by an automatic clamping bolt of the maneuvering lever, during the march, so that the breech can not be unscrewed. Finally, the hand of the man unloading can never be injured even when the breech is closed before he has withdrawn it.

The breech mechanism can be very easily assembled and taken apart. In reality there are only three pieces to remove -the operating lever with its firing pin, the extractor, and the body of the screw. As for the replacement of a firing pin, it can be made in a few seconds.

CARRIAGE.

The gun rests by a vertical trunnion in a cradle which is suspended from the flasks by two horizontal trunnions. Upon the axle are mounted two eccentrics, to which the wheel shoes are attached.

A cross brace unites these under the cheeks. During the march the system is raised to hook it up under the flasks. In this position the shoes can be pressed against the wheels by means of a handle placed within reach of the cannoneers on the seats and serve as traveling brakes.

For firing, the cross brace or tie-rod is unhooked and the shoes fall to the ground immediately behind the wheels. Chains unite the shoes to a helical spring seated between the flasks, which is extended during the recoil. That terminated, the spring contracting, aids the piece to descend the inclined plane of the shoes and resume its first position.

The Belgian artillery has just adopted a similar brake for its present material, described in volume 26 of the twenty-fifth year.

The gun is capable of a lateral displacement of about 3° on each side of the axis of the carriage.

All parts are made of special steel, and as at the beginning of the movement the carriage can recoil without being checked, it has been possible by the aid of the quality of steel used to give the material the solidity and simplicity which are the indispensable qualities of good field material.

LIMBER AND CAISSON.

We deem it useless to enter into the details on the subject of these carriages, of which the plates give a sufficient idea.

PRINCIPAL DIMENSIONS OF MATERIAL WITH LARGE WHEELS.

Caliber of gun	millimeters	75	= inches	2.953
Length of bore, in calibers	calibers	30	= inches	88.59
Total length of gun	millimeters	2,408	= inches	94.875
Weight of gun with sight and breech mechanism	kilograms	345	= pounds	760.73
Weight of carriage, complete	kilograms	662	= pounds	1,459.71
Weight of gun and carriage	kilograms	1,007	= pounds	2,220.44
Weight of limber, with ammunition chests empty, and accessories	kilograms	517	= pounds	1,138.98
Weight of limber loaded with 40 rounds	kilograms	846	= pounds	1,865.43
Weight of gun and carriage, complete, with 40 rounds and accessories	kilograms	1,853	= pounds	4,085.87
Diameter of wheels	millimeters	1,472	= inches	58
Gauge of track	millimeters	1,506	= inches	59.34
Weight of empty case	kilogram	0.965	= pounds	2.123
Weight of projectile	kilograms	6.500	= pounds	14.33
Initial velocity	m. s.	525	= f. s.	1,721.53

PRINCIPAL DIMENSIONS OF MATERIAL WITH SMALL WHEELS.

Caliber of gun	millimeters	75	= inches	2.953
Length of bore, in calibers	calibers	30	= inches	88.59
Total length of gun	millimeters	2,408	= inches	94.875
Weight of gun with sight and breech mechanism	kilograms	345	= pounds	760.73
Weight of carriage, complete	kilograms	622	= pounds	1,371.51
Weight of gun and carriage	kilograms	967	= pounds	2,132.24
Weight of limber with ammunition chests and accessories	kilograms	505	= pounds	1,113.53
Weight of limber loaded with 40 rounds	kilograms	818	= pounds	1,803.69
Weight of gun and carriage, complete, with 40 rounds and accessories	kilograms	1,785	= pounds	3,935.93
Diameter of wheels	millimeters	1,320	= inches	52
Gauge of track	millimeters	1,400	= inches	51.12
Weight of empty case	kilogram	0.818	= pounds	1.804
Weight of projectile	kilograms	6.500	= pounds	14.33
Initial velocity	m. s.	500	= f. s.	1,640.5

In Switzerland the Nordenfelt carriage presented differs from the latter in the replacement of the seats of the cannoneers by a footboard, upon which the men stand upright.

The total weight of the gun and carriage in this system is 1,720 kilograms = 3,792.6 pounds. It is, therefore, the lightest material of all.

(To be continued.)

UPON THE FORM OF THE HEAD OF OBLONG PROJECTILES WHICH ENCOUNTERS THE MINIMUM RESISTANCE TO MOTION FROM THE AIR.

[Reprinted from *La Corrispondenza.*]

1. The form usually given to projectiles, now-a-days, does not leave much to be desired in the direction of the resistance to motion, the preservation of the velocity and the stability during flight; yet it can not be said that the utmost possible has been done to diminish the resistance of the medium. Assuming that, for intrinsic reasons, the body of the projectile must be kept cylindrical, that the resistance is supposed to act direct and that the friction of the particles of air flowing along the sides of the projectiles may be neglected, the resistance depends exclusively upon the form of the head. Hence, desiring to undertake the determination of the surface of minimum resistance, it will suffice to restrict the study to the form of the head. The case, then, is but a consideration of an old solution of the problem given by General Piobert, by designing an ovoid projectile, which, like a ship, is quite rounded at the rear; this form was unstable and hence lacked precision of fire.

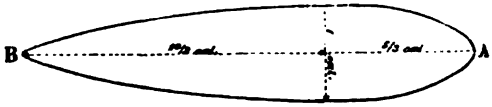


Fig. 1.

Major Ingalls of the U. S. Artillery published, in the latter part of April, 1895,* an interesting note in which, basing his discussion upon Duchemin's formula, he compares the resistances to motion encountered by various forms of heads, ogival, parabaloidal and conical, but nowhere in this study does the illustrious author touch upon the subject (quite as important as every other condition) of the determination of the form of the head of minimum resistance.

Later, in 1897, Lieutenant Bencivenga of the Italian Artillery published† a study entitled: 'Upon the generating curve of the ogival surface of projectiles with reference to the resistance of the air,' in which he proposed the problem of the investigation of the form of the head of minimum resistance. At a certain point of his discussion, however, believing that analysis might not furnish a sufficient guide for the solution of the problem, he strayed from the highway to plunge into a series of artifices which, notwithstanding their ingenuity, profoundly injure the scientific rigour of the research and lead to some inaccurate results which alter the intrinsic nature of the problem.

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* The resistance of the air to the motion of oblong projectiles as influenced by the shape of the head, by J. Ingalls, *Journal of the U. S. Artillery*, 1895.

† *Rivista d'Artiglieria e Genio*, Luglio-Agosto 1897.

The object of this note is to restore the above research to mathematical accuracy, to solve the problem completely and rigourously and to present an easy and expeditious means which should serve, in every case, to determine the form of the head of minimum resistance.

Finally, we will compare the various forms of heads with a view to the resistance which they encounter and, the length of the head being giving in calibers, will determine the ogive of minimum resistance.

2. Following Bencivenga we will limit our study, for the present, to the case of quadratic resistance as deduced by Newton,* and confirmed by experiment for velocities less than 240 m. and greater than 420 m. It is moreover interesting to observe at this point that it is of the greatest importance to diminish the resistance of the medium to the highest velocities, as it is precisely in such cases that it acquires very considerable values.

Let b be an empirical coefficient of resistance and $d\,A$ an element of the surface, moving with a velocity v, whose normal is inclined to the direction of motion by the angle ϵ, then will the resistance of the air encountered by it, designated by $d\,R_0$, be given by the known formula

$$(1) \qquad d\,R_0 = \frac{b\,\Delta}{g}\,d\,A\,v^2\cos^2\epsilon$$

in which Δ is the actual weight of a cubic meter of air and g the acceleration of gravity.

Let $y = f\,(x,\,a)$, in which a is independent of x, denote the general equation of the generating curve of the head of the projectile referred to two rectangular axes, $O\,x$ and $O\,y$, the origin being in the plane of the base of the head and $O\,y$ being coincident with the axis of figure of the projectile, and let us assume the surface of the head divided into elementary surfaces by a system of parallels and meridians, then will the resistance upon one of these elements, belonging to a given elementary zone whose normal is inclined to Oy by the acute angle ε, be given by (1), since it is assumed that the direction of motion is that of the axis of figure of the projectile.

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* See also: Sulla legge di resistenza dell'aria al moto dei proiettili, di A. Bassani. *La Corrispondenza*, parte V-VI, 1900.

Resolving this resistance into two components, one in the direction of motion, and the other in the direction perpendicular to it, it is easy to see that the first becomes

$$dR_1 = \frac{b\varDelta}{g}\, dA\, v^2 \cos^2 \varepsilon,$$

whilst the second is neutralised by an equal and contrary component of the resistance acting upon the element of the same zone which is symmetrically opposite the first.

It is evident that if we sum up all the resistances acting over the zone considered and bear in mind that for a surface of revolution

$$dA = 2\pi x\, ds = 2\pi x\, dx \sqrt{1 + [f'(x, a)]^2}$$

we will have for the resistance encountered by the above zone, the following expression:

$$dR = \frac{2\pi b \varDelta}{g} v^2 \cos^3 \varepsilon\, x\, dx \sqrt{1 + [f'(x, a)]^2}$$

Integrating this last expression between the limits r_0 and r, in which r_0 is the initial value of x, that is, the radius of the aperture of the point and r, the radius of the base of the projectile, we obtain

$$R = \frac{2\pi b \varDelta}{g} v^2 \int_{r_0}^{r} x \cos^3 \varepsilon\, dx \sqrt{1 + [f'(x, a)]^2}$$

which gives the total resistance acting upon the projectile.

But $\cos \varepsilon = \frac{dx}{ds} = \frac{1}{\sqrt{1 + [f'(x, a)]^2}}$ whence, by substituting in the preceding equation we have, finally

$$(2) \qquad R = \frac{2\pi b \varDelta}{g} v^2 \int_{r_0}^{r} \frac{x\, dx}{1 + [f'(x, a)]^2}.$$

From this it follows that the resistance is not only proportional to the square of the velocity but also to an integral factor depending exclusively upon the form of the head; hence the latter is the factor which must be made a minimum in order to obtain the form of minimum resistance; in other words, we may say that the condition of the problem we have proposed is represented by the equation

$$(3) \qquad \int_{r_0}^{r} \frac{x\, dx}{1 + [f'(x, a)]^2} = \text{minimum}.$$

Now it is known that for every value of the parameter a, equation (1) will represent a corresponding curve in the plane $x\,O\,y$, so that by assigning all possible values to a, the same equation serves to individualize not only a single curve, but an infinite system of curves lying in that plane. Moreover, if we assume that the ordinates (which are independent of a) corresponding to the abscissas r_0 and r are $y = H$ (length of the head) and $y = O$, respectively, all the curves of the above system will have in common the two points (r_0, H) and (r, O). It is a question, then, of determining which of these curves satisfies the minimum indicated above.

In order that expression (3) may be a minimum, we must have

$$\frac{d}{d\,a}\int_{r_0}^{r}\frac{x\,d\,x}{1+[f'\,(x,\,a)]^2} = 0$$

or, differentiating under the sign of integration, we have

$$\int_{r_0}^{r}\frac{x\,f'\,(x,\,a)}{\{\,1+[f'\,(x,\,a)]^2\,\}^2}\;\frac{d^2 f(x,\,a)}{d\,x\,d\,a}\,d\,x = 0$$

whence, integrating by parts, we have

$$\left|\frac{d f(x,\,a)}{d\,a}\;\frac{x\,f'\,(x,\,a)}{\{\,1+[f'\,(x,\,a)]^2\}^2}\right|_{r_0}^{r} - \int_{r_0}^{r}\frac{d f(x,\,a)}{d\,a}\,d.\,\frac{x\,f'\,(x,\,a)}{\{\,1+[f'\,(x,a)]^2\}^2} = 0.$$

But as, in the points of the abcissas, r_0 and r, common to all the curves, y is independent of a, $\frac{d\,y}{d\,a} = 0$, and hence the first term of the above expression reduces to zero.

There but remains, then, to place the second term of the expression equal to zero; but as the relation $\frac{d\,y}{d\,a}$, in the interval between r_0 and r (excluding the extremes) is never zero, the integral of the above factor between the same limits must be a constant, that is we will have

$$(4) \qquad \frac{x\,f'\,(x,\,a)}{\{1+[f'\,(x,\,a)]^2\}^2} + c = 0,$$

c being a constant of integration to be determined.

But y diminishes as x incrases, hence $\frac{d\,y}{d\,x} = f'\,(x,\,a)$ must be less than zero; therefore, placing, for brevity, $\frac{d\,y}{d\,x} = -p$, the preceding equation will take the form

(5) $$\frac{x}{c} = \frac{(1+p^2)^2}{p}$$

from which, by differentiation, we have

$$dx + x\frac{dp}{p} = 4c(1+p^2)\,dp$$

or, substituting for $-p\,dx$ its value, dy and for $\frac{x}{c}$ its value given in (5), we have

$$\frac{dy}{c} = \left(-3p^3 - 2p + \frac{1}{p}\right) dp$$

which, by integration gives

(6) $$\frac{y}{c} = -\frac{3}{4}p^4 - p^2 + Lp + k$$

in which L is the symbol for the Naperian logarith and k a constant of integration.

At this point it suffices to eliminate p between equations (5) and (6), so as to determine from the assumed conditions the constants c and k; we will thus arrive at a relation between x and y which is the desired equation of the generating curve of the head of minimum resistance.

To accomplish this, (5) may be put under the form

(7) $$p^4 + 2p^2 - \frac{x}{c}p + 1 = 0$$

which is a quartic with two imaginary roots, as one term is lacking between two having the same sign. Now in order that the equation may admit of two real roots, it is necessary and sufficient that the discriminant be either zero or negative, that is to say, that we have

$$I^3 - 27J \leqq 0$$

I and J being the invariants of the equation.

But in equation (7) above, we have

$$I = 1 + \frac{1}{3} \text{ and } J = \frac{1}{3} - \frac{1}{27} - \frac{x^2}{16c^2},$$

hence we must have

$$\frac{x^2}{c^2}\left(1 - \frac{27}{16^2}\frac{x^2}{c^2}\right) \leqq 0,$$

or since, from equation (5) $\frac{x}{c}$ can never become zero and has the same sign as p, which is always positive, we must have

(8) $$\frac{x}{c} \geqq \frac{16}{3\sqrt{3}} = 3.079 \text{ nearly.}$$

The resolvent of (3) is

$$z^3 - 2z^2 - 4z - \left(\frac{x^2}{c^2} - 8\right) = 0,$$

in which, for values of $\frac{x}{c}$ equal to or greater than $\frac{16}{3\sqrt{3}}$, the last term is negative, the discriminant, moreover, being negative in any case ; hence, it admits, on this hypothesis, a single root, real and positive, which is given by the relation

$$z_1 = \frac{1}{3}\left[2 + \sqrt[3]{\frac{1}{2}(\sigma - 3\sqrt{3\Delta})} + \sqrt[3]{\frac{1}{3}(\sigma - 3\sqrt{3\Delta})}\right]$$

in which

$$\sigma = 27\frac{x^2}{c^2} - 128$$

and

$$\Delta = 27\frac{x^4}{c^4} - 256\frac{x^2}{c^2} + 1408.$$

Now indicating by λ_1 and λ_2 ($\lambda_1 > \lambda_2$) the two roots, evidently positive, of the equation

(9) $$a^2 - z_1 a + 1 = 0$$

we may write, as can be easily verified,

$$p^4 + 2p^2 - \frac{x}{c}p + 1 = \left(p^2 + \frac{x}{c(\lambda_1 - \lambda_2)}p + \lambda_1\right)$$
$$\left(p^2 - \frac{x}{c(\lambda_1 - \lambda_2)}p + \lambda_2\right) = 0$$

and therefore, imposing the conditions that $\frac{x}{c}$ shall satisfy (8), we have

(10) $$\begin{aligned} p &= -\frac{x}{2c(\lambda_1 - \lambda_2)} \pm \sqrt{\frac{x^2}{4c^2(\lambda_1 - \lambda_2)^2} - \lambda_1} \\ p &= \frac{x}{2c(\lambda_1 - \lambda_2)} \pm \sqrt{\frac{x^2}{4c^2(\lambda_1 - \lambda_2)^2} - \lambda_2} \end{aligned}$$

which are the four roots of equation (7).

Let us omit from consideration the first two roots, which are imaginary and, therefore, incapable of satisfying the problem, and taking up the other two which, as we have seen, are both real and positive.

For $\frac{x}{c} = \frac{16}{3\sqrt{3}}$ these two roots become equal, the corresponding value of p, under this assumption, being

$$p = \frac{1}{\sqrt{3}} = 0.5773 \text{ nearly.}$$

As $\frac{x}{c}$ increases from the value $\frac{16}{3\sqrt{3}}$, (it can not be less than this value, as shown above), p assumes two series of corresponding values, one increasing from $p = \frac{1}{\sqrt{3}}$ to $p = \infty$, the other decreasing from $p = \frac{1}{\sqrt{3}}$ to $p = 0$. These two series of values of the variable p, the latter being the trigonometrical tangent of the angle which the tangent to the generating curve sought makes with the axis $O\,x$, evidently determine two special curves, the first of which (relating to the series of increasing values of p) is concave toward the axis of y, whilst the other is convex towards this axis.

We shall soon see whether both of these curves or but one of them can enter into the solution of the problem; meanwhile it will be expedient to designate by $p_{\frac{x}{c}}$ one of the two values of p given by the second of (10).

Replacing. in this last equatisn, λ_1 and λ_2 by their values as deduced from (9), we obtain

$$(11) \qquad p = p_{\frac{x}{c}} = \frac{x}{2\,c\sqrt{z_1^2 - 4}} \pm \sqrt{\frac{x^2}{4\,c^2(z_1^2 - 4)} - \frac{z_1 - \sqrt{z_1^2 - 4}}{2}}.$$

From (5) and (6), replacing p by $p_{\frac{x}{c}}$, we obtain

$$(12) \qquad k - \frac{y}{c} = \frac{3\,x}{4\,c}\,p_{\frac{x}{c}} - \frac{1}{2}\,p^2_{\frac{x}{c}} - L\,p_{\frac{x}{c}} - 1$$

which is an equation between x and y containing the unknown constants k and c. The first of these is easily found by observing that the abcissa r_0 of the point of the curve having the maximum ordinate H, may be selected at random, provided the condition $\frac{r_0}{c} \geqq \frac{16}{3\sqrt{3}}$ remains satisfied; if, however, we agree to take the smallest value of r_0* or $r_0 = \frac{16\,c}{3\sqrt{3}}$, and substitute in (12) this value for x, and H for y, knowing that then $p_{\frac{x}{c}}$ becomes equal to $\frac{1}{\sqrt{3}}$, we will have

$$k - \frac{H}{c} = 0.716.$$

It is evident that if we eliminate k between this equation and (12), we will have

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* We will see in what follows that, taking for r_0 any other value whatsoever, the process of the operation remains the same.

$$(13)\qquad \frac{H-y}{c} = \frac{3}{4}\frac{x}{c}p_{\frac{x}{c}} - \frac{1}{2}p^2_{\frac{x}{c}} - Lp_{\frac{x}{c}} - 1.716$$

in which there but remains to determine the constant c.

To accomplish this, we designate by $p_{\frac{r}{c}}$ the value of p at the point (r, O) and place $x = r$ and $y = O$ in the preceding equation, and thus obtain

$$(14)\qquad \frac{H}{c} = \frac{3}{4}\frac{r}{c}p_{\frac{r}{c}} - \frac{1}{2}p^2_{\frac{r}{c}} - Lp_{\frac{r}{c}} - 1.716$$

from which the value of the constant c can be determined as follows: assume any value for c, form the ratio $\frac{r}{c}$ and calculate $p_{\frac{r}{c}}$; the deduce $\frac{H}{c}$ from (14) and calculate H. If this value of H is the same as the given value, the value of c assumed is the one sought, if not repeat the process, increasing or diminishing conveniently the first value of c. But we have seen that every value of $\frac{x}{c}$ gives two distinct positive values ot $p_{\frac{x}{c}}$, and hence for every value of $\frac{r}{c}$ we will also find two distinct values of $p_{\frac{x}{c}}$, whence it is first necessary to show which of these values ought to be considered. In this strait we take $x = r$ in (5), which then becomes

$$\frac{r}{c} = \frac{\left(1 + p^2_{\frac{r}{c}}\right)^2}{p_{\frac{x}{c}}}$$

and, dividing (14) by the latter, member for member, we obtain

$$\frac{H}{c} = \frac{p_{\frac{r}{c}}\left[\frac{3}{4}\left(1 + p^2_{\frac{r}{c}}\right)^2 - \frac{1}{2}p^2_{\frac{r}{c}} - Lp_{\frac{r}{c}} - 1.716\right]}{\left(1 + p^2_{\frac{r}{c}}\right)^2}.$$

But the length H, for all forms of heads, is always greater than, or at least equal to, the radius of the base of the projectile, so that $\frac{H}{r}$ must be either greater than unity or at least equal to it. Hence the second member must also satisfy this condition; this, however, is impossible unless $p_{\frac{r}{c}}$ is greater than unity, that is, unless $p_{\frac{r}{c}}$ belong to the series of increasing values of p. Hence we will only need to consider the positive sign before the radical in equation (11) and the generating curve sought will, in every case, be concave towards the axis Oy. Thus every ambiguity is removed and for every value of $\frac{r}{c}$ we will be able to determine the corresponding value of $p_{\frac{r}{c}}$. But the determination of the constant c by the method by trials from (14), as indicated above, presents the serious inconvenience of being long and vexatious. In order to avoid this difficulty we have constructed the annexed table, which gives the values of $\frac{x}{c}$ corresponding to those of $\frac{H-y}{c}$ and $p_{\frac{x}{c}}$.

$p_{\frac{x}{c}}$	$\frac{x}{c}$		$\frac{H-y}{c}$		$p_{\frac{x}{c}}$	$\frac{x}{c}$		$\frac{H-y}{c}$	
0,5773	3,08		0,00		1,9	11,18	61	11,78	115
0,7	3,17		0,06		1,95	11,82	64	13,01	123
0,8	3,36	19	0,20	14	2	12,50	68	14,34	133
0,9	3,64	28	0,44	24	2,05	13,20	70	15,76	142
1	4,00	36	0,78	34	2,1	13,94	74	17,29	153
1,1	4,44	44	1,25	47	2,15	14,70	76	18,92	163
1,15	4,69	25	1,53	28	2,2	15,50	80	20,65	173
1,2	4,96	27	1,85	32	2,25	16,33	83	22,51	186
1,25	5,25	29	2,20	35	2,3	17,20	87	24,48	197
1,3	5,56	31	2,60	40	2,35	18,20	90	26,57	209
1,35	5,90	34	3,05	44	2,4	19,04	94	28,80	223
1,4	6,26	36	3,54	49	2,45	20,01	97	31,16	236
1,45	6,64	38	4,08	54	2,5	21,02	101	33,66	250
1,5	7,04	40	4,67	59	2,55	22,07	105	36,31	265
1,55	7,47	43	5,33	66	2,6	23,16	109	39,11	280
1,6	7,92	45	6,04	71	2,65	24,29	113	42,07	296
1,65	8,40	48	6,81	77	2,7	25,45	116	45,19	312
1,7	8,90	50	7,66	85	2,75	26,66	121	48,48	329
1,75	9,43	53	8,57	91	2,8	27,91	125	51,94	346
1,8	9,99	56	9,56	99	2,85	29,20	129	55,59	365
1,85	10,63	58	10,63	107	2,9	30,53	133	59,42	383

$p_{\frac{x}{c}}$	$\frac{x}{c}$		$\frac{H-y}{c}$		$p_{\frac{x}{c}}$	$\frac{x}{c}$		$\frac{H-y}{c}$	
2,95	31,91	138	63,45	403	4	72,25	247	205,56	981
3	33,33	142	67,68	423	4,05	74,77	252	215,82	1017
3,05	34,80	147	72,12	444	4,1	77,36	259	226,35	1053
3,1	36,31	151	76,77	465	4,15	80,01	265	237,29	1094
3,15	37,87	156	81,65	488	4,2	82,72	271	248,62	1133
3,2	39,48	161	86,75	510	4,25	85,50	278	260,34	1172
3,25	41,14	166	92,09	534	4,3	88,34	284	272,49	1215
3,3	42,84	170	97,67	558	4,35	91,24	290	285,08	1259
3,35	44,59	175	103,51	584	4,4	94,21	297	298,02	1294
3,4	46,39	180	109,59	608	4,45	97,24	303	311,42	1340
3,45	48,25	186	115,95	636	4,5	100,35	311	325,32	1390
3,5	50,16	191	122,58	663	4,45	103,51	316	339,67	1435
3,55	52,12	196	129,49	691	4,6	106,75	324	354,48	1481
3,6	54,13	201	136,68	719	4,65	110,06	331	369,77	1529
3,65	56,20	207	144,17	749	4,7	113,43	337	385,55	1578
3,7	58,32	212	151,98	780	4,75	116,88	345	401,84	1629
3,75	60,50	218	160,09	811	4,8	120,40	352	418,64	1680
3,8	62,73	223	168,52	843	4,85	123,99	359	435,96	1732
3,85	65,03	230	177,29	877	4,9	127,65	366	453,81	1785
3,9	67,38	235	186,39	910	4,95	131,39	374	472,22	1841
3,95	69,78	240	195,84	945	5	135,20	381	491,17	1895

This table is used in the following manner: given H and r, we form the factor $\frac{r}{c}$, assigning to c some suitable value; with this factor as an argument we enter the column $\frac{x}{c}$ and take from the adjacent column the corresponding value of $\frac{H-y}{c}$, which, in this case is equal to $\frac{H}{c}$, since, when $x = r$, $y = O$, and, knowing H, we deduce c. If this value of c is the same as the one assumed, the result is exact, if not, we make another trial.[*]

It is proper to observe that H is generally given in calibers so that r can be placed equal to .5. Then, H being, for example, .5 calibers, it will suffice to find in the second and third columns of the table, two corresponding values which are equal, from which, as they are each equal to $\frac{1}{2c}$, c can be immediately determined. If $H = 1$ caliber, it will suffice to find in the same two colums, two corresponding values such that the second is double the first, the reciprocal of the latter will be the value of c sought.

In general, if $H = \mu$ calibers, it will suffice to find in the same two colums, two corresponding values such that the second is 2μ times the first; then half the reciprocal of the latter will be the value of c sought.

[Translated by Captain Frank E. Harris, Artillery Corps.]

(To be continued).

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[*] If instead of the smallest value of r_0, taken above, we take any other as, for example, a, and denote the corresponding length of the head by H', we will obtain from (12), denoting the second member of (13) by $F\left(\frac{x}{c}\right)$

$$k - \frac{y}{c} = F\left(\frac{x}{c}\right) + 0.716.$$

Making $x = r$ and $y = O$, we have

$$k = F\left(\frac{r}{c}\right) + 0.716,$$

whence, subtracting the former from the latter, member from member, we obtain

$$(\alpha) \qquad \frac{y}{c} = F\left(\frac{r}{c}\right) - F\left(\frac{x}{c}\right).$$

To obtain the constant c from this equation, we make $x = a$, whence $y = H'$. we obtain

$$(\beta) \qquad \frac{H'}{c} = F\left(\frac{r}{c}\right) - F\left(\frac{a}{c}\right),$$

whence, with the aid of the table, we can immediately deduce the value of c, since the numbers tabulated in column 3 of the table are the values of the function $F\frac{x}{c}$ corresponding to the variable $\frac{x}{c}$. Having determined c in the manner indicated, formula (α) will furnish a ready means of calculate the curve by points.

A CHAT ON MILITARY HISTORY AND THE ART OF WAR.

BY OTTO GREBTOG.

Translated from *New Yorker Staats-Zeitung*, May 12, 1901, by Dr. Otto Plate, Librarian, U. S. M. A.

Not only the student of the humanities, but also the soldier finds in Homer, Xenophon, and Caesar, classics of the highest rank. Homer is to him a military writer of able judgment in questions of tactics; for example, he says of Menestheus:

"Whom no chief
On earth could equal in the art to place
Squadron of men and horse in the array
For battle."

That even his contemporaries and their descendants seriously regarded the author of the Iliad as a tactician is shown by the papers of Hermias and Stratokles on Homer's tactics. Later in history, the men of the sword themselves take up the pen. Caesar writes his commentaries of the Gallic Wars, quite conscious of himself, and not altogether free from vanity, for like Napoleon in his bulletins, he keeps his own person steadily in the foreground. The author of the Anabasis on the contrary writes, like Moltke, in a concise practical way, avoiding as much as possible the interruption of his narrative by the introduction of an account of his personal achievements.

The works of these two great men of the sword as well as of the pen remained until the middle of the 18th century the fountainhead of all military science. Even to-day we revert to them.

It is not to be regarded as a pleasantry that William II engaged the French General Staff in a discussion on an opinion of Caesar. As a curious student of war he was anxious to learn the views of people who could follow on the spot the traces of the great Roman. The influence of Xenophon on the art of war is naturally less than Caesar's. In the main he describes a retreat executed in a masterly way; but at the same time when he advocates the doing away with the phalanx and a return to the Doric order of fighting, he is laying down tactical rules that were overthrown only in the time of the line of skirmishers. Caesar on the other hand provided soldiers for a thousand years with instructions in all departments of military life, many of which were not displaced by more suitable ones until the middle of the last century. As a strategian he is counted to-day among the very greatest; as a tactician, probably Frederick alone has outdone him; his rules for field fortifications were followed until late in the Middle Ages, and the bridge which he threw across the Rhine (on account of which we swear at him in Tertia), was decidedly better than Blucher's at Caub.

The productions of the Middle Ages remained far behind such writings. These times knew no military writer of breadth of view; the writers exhausted themselves in trivialities such as orders of battle, regulations for parking wagons, and tourney rules, and were busied with receipts for gun-fire and Greek fire. The sources of military science seemed still to be dried up in the days of Turenne and Eugene. Frederick makes them burst anew. He was not only a writer himself but he animates others with the love of study, even beyond the boundaries of his own kingdom. Algarotti, for example, was his pupil in military writing.

When at the end of the 18th century arose the sun of Bonaparte, an eager student of military science, France naturally became authority in the realm of the art of war and military literature. But immediately after Jena there is to be seen in Germany the dawn of a classical period of military literature. At this time we see it become international property in a way that can be said of no other branch of literature. As soon as a new thinker makes his influence felt, his teachings become the property of all armies. It is by no means among the great military powers solely that the finest productions of this literature appear. Military specialists of all nations are called upon from time to time to give attention to the voice of Belgium, once the leader in the art of fortification; Switzerland also whose military periodicals are esteemed among the best of all lands, has at this period a flourishing military literature. Nor is this to be wondered at, for it is not essential that a military writer should be a soldier. Bernhardi, one of the greatest of military writers, never wore a sword. The theory of war is a pure science, for which the leading of troops is a desirable preparatory school, but not an indispensable one. Moltke was not an able soldier, in the usual sense. He was never employed to lead troops because he was not fitted for it; yet he was a distinguished scholar in the domain of military science. Men shook their heads when he was called to his high station, for in Prussia they were accustomed to be led by men of a soldierly nature, and they held the closet student in little esteem.

Probably nothing proves William I's sure knowledge of men to such a degree as this very selection of Moltke for the most responsible place in an army which was not deficient in capable generals. But let us return to the beginning of the nineteenth century, when no exact expression for military science had been found. Buelow's "Formalism" was intended to bring mathematics into the service of the tactician, and prepared the way for Jomini's "Methodics." Eyes were now turned again from the Belgians and the French to Prussia, where Berenhorst came forth with his severe rejection of science, and asserted that the art of war is not to be considered as a science. Only then, Clausewitz, the Lessing of military literature, places the study of war upon a philosophical basis. To this greatest of all military theorists war appears merely as an act of human intercourse, only to be distinguished from other kinds of intercourse in that it is bloody. He also created a new dress for military writing by expressing his ideas with classic clearness in sentences as neat and unadorned as the Prussian uniform. When we hear of Moltke's purity and precision of language we must not forget Clausewitz. Since his appearance, Germany has remained the leader in military literature. Especially in the Prussian army does the love of study strive; a whole list of men ripen in a long period of peace not only to generals, but also into scholars, and even in non military domains especially in historical and geographical investigations. This influence served to deepen military literature. Then three great wars broadened the field and the three works of the General Staff were composed, whose descriptions of war were of a completeness, extent, and accuracy, that had never before been known, and which will remain for all time monuments of German thoroughness. Though indeed these productions are called for brevity Moltke's General Staff Work of 1870-71, it would be an error to think that Moltke was their author. It came from the pens of vorious writers, all of whom belonged to the German General Staff. That the General Staff is composed of specialists is well known, but we find in it also scholars in other branches of science. Two of its officers died in East Asia, York (von Wartenberg), a historian whose "History of Napoleon" has been translated into all languages, and Schwarzhoff, a political economist, who in a single speech convinced former opponents of so-called militarism that standing armies are not in reality injurious to economical interests; he was nominated a *doctor honoris causa*, of a German university, after the savants of the whole civilized world had complimented him, because he had made them aware of an entirely new point of view. That such a General Staff could produce works which will form historical monuments is not astonishing; it is surprising, however, that these do not only breathe the spirit of Moltke, but word by word remind us of his style of writing, although he gave only the directions for the execution of the separate episodes. What a proof is this of the way in which Moltke trained up his pupils!

Besides these anonymous writers of the works of the General Staff, there arose after the war a series of men, some of whom narrated events in their own way, differing from the official investigation, while others drew inferences from the facts for the future. Kühne wrote the world famous Critical Journeys over the Battlefields of Bohemia. Jensen and Lettow-Vorbeck became recognized as military historians, Boguslawski and Meckel as tacticians. Other and perhaps equally great names might be added, if space permitted. Yet all these writers thought and wrote like the authors of the work of the General Staff, simply as Prussian officers. Criticism suffered from this. There was a disinclination to animadvert upon the faults of famous generals of established reputation, because this was offensive to Prussian tradition. Besides, it was held vulgar in this literature to indulge in personal references. At most, names were mentioned, but neither in praise nor in blame. Perhaps for these reasons the works of the General Staff seem to be the quintessence of tediousness to the layman. We read in classic German that this brigade marched hither and that battalion marched thither, but because we find nothing of persons and their experiences we lose that interest which we take in what has actually occured.

During the last fifteen years, the influence of a man has made itself felt of whom we may boldly say that he has created a new German military literature,—Hoenig! Undoubtedly he stands to-day in this field, the greatest living authority in the world. In his writings, he broke through the limitations of tradition, destroyed legends and in the interest of truth plucked many a leaf from the laurel wreaths of great army commanders. He was attacked for this, given the lie, and they overwhelmed the sensitive, nervous, and half-blind man with unmeasured bitter criticism. He silently went on his way. Only once, at the end of one of his first works, do we read an exclamation: "If God leaves me my eyesight, I hope to convince my opponents." In this he was destined to succeed, for to-day he counts among his adherents and advocates the first generals of Germany, one of the warmest being the field marshall now in China, the confidential friend of his imperial master. We laymen are indebted to Hoenig, because he has made interesting, specialized military history, hitherto for the most part so tedious, and has shown how its mostly dry material may be treated in an entertaining way. In this, he has also done the specialist a great service. The works of the General Staff were too tedious to read through even for the average lieutenant, but Hoenig's manner of presenting a subject holds even the laymen like a romance that one dislikes to lay down before the knot has been loosened.

In contrast to the work of the General Staff, he attaches as much importance to the painting of character as to the relation of events, and his portraits of generals are masterpieces. Thus he shows us Steinitz and Goeben at Gravelotte, on each side of the great Chaussee. Steinmetz sits on his horse in the midst of his staff; he chews his mustache nervously; he jerks at the bridle of his horse, and thrusts his spurs into its flanks; he abuses the people about him, and falls a-cursing when he notices an erroneous movement of the troops. This restlessness of the commander, caused by the critical situation, naturally infects the subordinate leaders; they too become earnest and angry, there is much useless shouting and correcting, the troops are badly placed, and the leaders lose their patience on account of open fault-finding. Finally the whole army was worked into a state of nervous excitement that led to a panic-like flight of whole regiments, and were it not for the coming up of the Second Corps, a catastrophe had been inevitable. But on the far side of the highway we see Goeben. The gaunt figure, which at other times is bent, now sits bolt upright in the saddle, and motionless as if cast in metal; the eyes, usually listless, are now seen through the eye-glasses flashing the bright clear glance of the commander.

This calm of the man, who, looking in common life not unlike a schoolmaster, is now seemingly aroused by breathing the smoke of powder, has a quieting and reassuring effect upon the subordinate commanders, and upon the troops; and these therefore stand up to their duty. Such descriptions as these were unheard of in the Prussian army. It was regarded as a sacrilege against holy traditions, to thus present to the world the lion-hearted victor of Nachod. But worse was yet to come! In "Twenty-four Hours of Moltke's Strategy" Captain Hoenig found fault with the measures of Moltke and even of the royal commander-in-chief, and demonstrated with incontrovertible clearness, that even "the Great Taciturn" had his dark day. He blamed

Moltke for not having procured sufficient information before the battle of Gravelotte and said in substance: It was an unpardonable fault, that out of respect for the age of the grey-haired commander-in-chief the main headquarters rode back to Pont-à-Mousson, when its place was in the foremost line bivouacing with a battalion, in order that by the earliest break of day a judgment might be formed of the enemy's position. Upon this Hoenig was called the social democrat of military literature, and voices were not lacking that demanded that his captain's title should be taken away from him. At present however, we recognize that even if the very great men, William and Moltke, made mistakes, we must still take note of it, in order that smaller people may not imitate their errors under the impression that they are acting rightly. Unquestionably the most important work of Hoenig is the "People's War on the Loire" (Der Volkskrieg an der Loire). In this production he also destroys a legend that had become dear to the German people and army. He proves to us, that the commander in-chief, Frederick Charles, the Red Prince, was far from being the reckless cavalry general, which he was esteemed to be, but was rather a cautious and even hesitating general. Hoenig on this account does not diminish his merits, but emphasizes, how the Prince field marshal during three wars and in the most difficult situations did not lose a single battle, because he exercised this prudence. So great was this, that at the main headquarters he was reproached for a lack of bold decision, and an officer was even sent to supervise his work, in a certain measure, there was at one time some intention of taking away his command. Frederick Charles, we hear by the way, only walked his horse during the entire campaign of the Loire, while all pictures represent him as a madly galloping rider; but he does not become less dear to us, since Hoenig makes clear to us how this wise delayer was the right man in the right place. In like manner, Hoenig lays a crown of laurel upon the grave of many a quiet hero, whose deeds are not honored by higher historical reports, and he points out among the survivors of the war those who did capable service.

Another thing that makes his writings so interesting is the manner in which he weaves the smaller episodes into the course of his main narrative, about as Hiltl does in his works for laymen; and these smaller anecdotes are as authentic as the more unimportant events.

The following incident is typical. It is a characteristic story of General Schmidt, showing us how his subordinates feared him more than Death and the Devil. At least the author shows that they would rather rush to death than incur the anger of this superior, who in reality was a kindly hearted man. At the Loire, Schmidt was begged by a cavalry captain, on outpost duty, to send him two companies of infantry, as a reinforcement, so that he might retake a village from which his squadron had just been driven by a superior force of infantry. Schmidt sent him no aid, but rode up to the squadron, ordered the men to dismount, and said: "You have allowed yourself to be pitched out of the village; so you will get it back yourselves." Upon this, he drew his sword, and stormed the village leading the squadron. Events like these, too good to be forgotten, had hitherto been neglected by military history.

It is much to be regretted that of late Hoenig seems to have placed his abilities entirely at the service of the daily press. If this is so, the "Art of War" is trying to keep the pot a-boiling.

The United States too, in comparison with its small army, has a rich military literature, and before the Spanish war more was written by American officers than by those of other armies, probably because their work was lighter. It is to be hoped that the world will yet be indebted to their industry for a trustworthy account of the military events in the Philippines, for such as yet has been lacking, owing to the censorship.

THE MODERN BATTLE AND THE EFFECT OF NEW WEAPONS.

A paper read before the Massachusetts Military Historical Society by W. R. Livermore, Major of Engineers,* April 8, 1889.

Mr. President

And members of the Military Historical Society of Massachusetts.

You have kindly asked me to read you a paper this evening on the modern battle and to dwell upon those of its features wherein it differs most from the battle of our war, to express an opinion about the effect of new weapons in a collision between two great European Powers and to make some suggestion looking to further improvements.

Our civil war has been followed by a long peace and if we ourselves have failed to learn all its lessons, we have taught our pupils on the other side of the ocean to make good use of them, as their fathers made of the lessons of the American wars of the eighteenth century.

Our own innovations have been so developed in Continental Europe that those who have not been able to follow the tread of progress would scarcely recognize their origin.

A new science has been created and our nation is just beginning to study its alphabet.

The first impulse to the change of tactics was given in America and the weapons by which the changes have been wrought were invented in America.

The adoption of improved firearms by all European nations is the most obvious feature that distinguishes the new warfare from the old, but the substantial difference consists in the growth of ideas and the decay of prejudice.

Our war demonstrated the advantages of good weapons. Two or three years would have sufficed to bring them to their present state of perfection, but 25 years were required to overcome the sentiment in favor of bad weapons.

There is not a weapon nor a single feature of a weapon now held in esteem in Europe that was not deviced by Americans ten or fifteen years ago.

Now Lieutenant-Colonel, Military Attaché, U. S. Legation, Copenhagen, Denmark. The above paper, although written several years ago, is still very modern, and constitutes an interesting study in connection with the most recent wars.—Ed.

But the spirit of conservatism was opposed to such innovations. The advocates of bad weapons were most ingenious in their arguments and in their assumptions. Their mutual contradiction only commended them to a wider hearing and to more diversified tastes.

The spirit was the same. Bad weapons were practical; good ones were visionary.

In 1861 we were seriously taught to believe that a weapon to put in the hand of a soldier should be one that he could not break, and it was laid down as military axiom that a soldier would break his musket if he could. I cannot regard the sentiment a proper one to impart in the mind of a soldier.

The guns have been subjected to a series of tests, so severe that if they could resist them they would only be fit for a hand to hand fight. But we do not propose to give our enemies the same facilities for attacking our weapons with salamoniac, sand blasts, trip hammers and blast furnaces.

War and rumors of war have forced Europe to arm its forces with quick-firing, far-firing and straight-firing guns, and thus we are brought face to face with several objections that are urged against good guns based upon the various features of their superiority.

Objections are raised to long range firing because it is inaccurate; against accurate firing, because it is slow; against quick firing, because it is inaccurate and exhausts the ammunition.

It is very easy to object that after a man has fired all his ammunition he will have none left. But it is far more rational to state the problem thus: That the transportation required to bring ten days rations to an army of 10,000 men could bring 3,000,000 cartridges to an army of 1000 men. Then the smaller force could accomplish more with a good gun than ten times its number with a bad one.

Even now that magazine guns are recognized throughout Europe as the proper armament the old tradition yet hangs on that the magazine is only to be used at close quarters, and this arises from the impression that after the magazine is discharged the piece cannot be fired more quickly than a single loader.

This is no longer true with a good gun, for the magazine can be refilled with 6 rounds in 1 1/3 seconds and these 6 rounds can be discharged with proper accuracy in 5 seconds more making 50 or 60 rounds a minute. The cartridges are kept in tin cases and inserted in the magazine with a single motion. The piece can be reloaded by the effect of the recoil or by a single direct movement of the hand.

Other important factors in discriminating between battles of the past and present depend upon the employment of smaller calibers with flatter trajectories and of smokeless powder.

The improvements in mitrailleuses, in revolving cannons and quick firing cannons are of like character no less important in their sphere.

The field artillery of the modern battle will consist of mitrailleuses firing over 1000 rounds a minute, of revolving cannons of 1½ in. caliber projecting a still greater number of effective fragments, rifles from 3" to 3½" in caliber firing fixed ammunition at the rate of 6 and 12 rounds per minute respectively from carriages fixed to the ground and adapted to take up the recoil without destroying the aim.

The arm of the cavalry will be similar to that of the infantry but a little shorter in the barrel and in the stock.

Many horses and pack mules will carry ammunition alone.

The engineer troops will often be mounted and will be supplied with whatever their art requires. Troops of all arms carry intrenching tools, range finders, etc.

The field telegraph will be the main dependence of the Commander-in-Chief in arranging his dispositions for combat.

The proportion of the three arms will not vary much from those of Napoleonic times, 4 guns, 200 cavalry to 1000 infantry would be a good proportion for an open country.

Infantry and cavalry will be well supplied with light mitrailleuses of the self loading type.

The war of 1870 gave great prominence to the artillery but in 1877 its improper use by the Russians led to the belief in some minds that its days were numbered. Nothing could be more contrary to the spirit of modern warfare unless it be the opinion that cavalry is no longer useful on a battle field but must be relegated to the duty of reconnaissance and outpost work.

There is even more scope now than before for grand tactical maneuvres of cavalry in connection with mitrailleuses and guns of all calibers.

The general effect of the improvements in fire arms is to reduce all deliberately planned battles to the attack and defence of fortified positions, for so great is the immediate advantage to be derived from the protection of hasty entrenchments and natural cover that the defence will always avail itself of every opportunity for its use. Obstacles in front of a defensive position are no longer as essential as formerly. A free and open field of fire is the best obstacle to an attack provided there is nothing to obstruct the view. Night attacks however will be more frequent than heretofore. The defenders will use smokeless powder but under favorable circumstances the attack will cover its advance by smoke balls thrown out in front of the defenders.

The principles of grand tactics are not affected by new conditions excepting that the same number of men are capable of occupying and defending a much longer line. But all tactics adopted in Europe still provide for a strength of 6 or 7 men per meter of front on the side of the attack. This includes the firing line, reinforcements, supports, reserves, second and third line.

A much weaker line is sufficient to hold a position against an assault; but it will be a long time before armies will be deployed over as wide a front as possible and the prevailing type of battle now consists of an attack along the whole line, combined with an enveloping movement on one flank. This movement will be opposed by the echelons in the rear but the attack will gain the advantage of conveying fire at the salient position on the flank of the original line.

The great battles between France and Germany partook of this general character, and if the defensive forces are inferior in number and efficiency, and remain concentrated on a narrow front, no other mode of attack is required, but after many such experiences the defenders will spread out to avoid such dangers and then with the evenly balanced advantages of centre and flank attack the genius of a Napoleon will again make itself felt on a battle field. Grand Tactics is not a dead science and even battles of the Austerlitz type are not merely affairs of the past.

The artillery reserve has fallen into disfavor and all European nations believe that the cavalry is no longer needed on the battle field.

This is perfectly true so long as one side is contented to allow the other to walk quietly around its wing and envelop it with a concentrated force. But the first to organize an efficient force of cavalry and horse artillery adapted to modern conditions will acquire an immense advantage.

This force can suddenly be directed upon the decisive point and take up a position to bring a concentrated fire on the enemy's line.

A great deal of statistical information about the effects of fire arms in battle has been accumulated during the past 20 years. The general result shows that on the battle field we should not expect to find more than one-tenth or one-twentieth the accuracy of target practice.

It also appears that during the attack the number of hits on a given target or hostile firing line is diminished by half for every 250 yards distance. This is approximately true from 300 to 2000 yards. It is due not merely to the widening of the sheaf of projectiles with the distance but the sheaf itself is more open and scattering, but this is by no means always objectionable and in the French and German service at least they are *made* to scatter by requiring the men to fire with different elevations.

Suppose now that two companies of infantry which in our service would comprise about 64 men each armed with breech-loading rifle muskets are deployed as skirmishers, lying down and firing at the rate of 6 rounds in a minute, and another line directly in front of it and distant about 500 yards also lying down in an open plain at intervals of about one and one quarter yards in a line at right angles to the line of fire and firing upon the first with about equal effect, and suppose the companies first mentioned to be composed of soldiers of average ability belonging to the offensive party perfectly fresh in the fight but long enough on the ground to have formed a fair conception of the distance, it will generally inflict a loss in killed and wounded of about one man a minute.

When troops in the field fire at each other at any considerable distance the accuracy of their fire is not sufficient to enable them to single out an individual in a skirmish line; but the shower of projectiles is about equally distributed over the area occupied by the hostile firing line.

If the companies above described were spreading out their fire over a large target, i. e., one composed of a *longer* line of skirmishers at intervals of one and one quarter yards the total number of killed and wounded would be the same. But if the *same* extent of line were occupied by twice the number of men, namely, by 250 men in single rank, it is probable that twice as many would be killed as in the former case.

Now suppose a battalion of 500 men in column of companies advances at a run directly towards the two companies of skirmishers 600 yards distant, its loss would amount to about 100 men for the first minute and 200 for the second, or a total loss of 60% of its effective strength by the time it arrived within 300 yards of the skirmishers.

Now suppose the two lines of skirmishers are firing upon each other 300 yards apart and reinforcements attempt to come up to relieve one of the lines—still assuming the ground to be level—the loss to the reinforcements would amount to more than one half of its effective strength before it reached this line, and if the defenders should make use of their magazines during the last minute, nine-tenths of the reinforcements would be killed or wounded. This carnage would all be produced by the accidental shots that were aimed at the firing line and passed over their heads; the loss to the firing line would be in no degree diminished.

These statements appear extravagant when compared with former conditions but the ball must follow a trajectory due to its initial velocity—and must go somewhere—it must strike the ground at a certain angle and in so doing it must sweep a given area.

The theory of probabilities enables us to determine how the shots are distributed, but the condition of the assaulting party would be in but little improved if the shots were distributed by other laws and in different proportions

The result of these calculations which are thoroughly borne out by the experience of recent wars demonstrates the necessity of taking advantage of the ground and driving off or demoralizing the defenders by concentrating upon them a long and heavy fire of musketry and artillery before attempting to advance.

We now come to consider the tactical formations which will enable an enemy equipped with the new weapons to operate against an enemy who enjoys the same advantages.

About ten years ago the state of the problem as it then stood so far as related to infantry was well analyzed in a brief paper by Col. Sir Lumley Graham, which was reprinted in our ordnance notes in 1883 and has been so frequently quoted that it derives an interest on this score entirely independent of its merit. It has contributed in some measure to draw attention to the necessity for a change in our system of drill tactics.

Of the principles laid down in this paper as already universally accepted by three at least of the great Continental powers, the following is the substance of those which are strictly applicable to the modern battle:

1. The firearm is undoubtedly mistress of the battle field.
2. The formation of infantry must favor the effect of its own fire and minimize that of the enemy.
6. Infantry fire must be entirely under control.

8. The loose formations are necessary to avoid loss but thorough discipline will enable the chain of responsibility to be maintained from the Commander-in-Chief right down to the leader of the smallest squad in the firing line.

12. The total force of infantry occupies a greater depth of ground than formerly being distributed into a greater number of lines.

14. Supports and reserves must be kept in close order in line or column and as well up to the front as possible.

15. Good infantry need not fear the attack of cavalry even if in extended order.

18. Improvements in firearms do not always favor the defense at the expense of the attack.

19. A mere passive defense will produce no great result.

The following however require modifications to meet the requirements of the modern battle :

3. For the front or "firing line" the only formation both in attack and defense, which meets the requirements is a line of small sections extended in single rank, which we English call a line of skirmishers, which from being at first very open becomes more and more dense, as the antagonists come to close quarters, attaining at last almost the consistency of a line in close quarters.

4. This firing line has a very different mission to that of the old "line of skirmishers."

The latter has only to prepare the way for the columns or lines and to supplement their efforts, the former on the contrary has to fight the battle out, throughout all its stages to the very conclusion, being supported in doing so by the troops in close order. Hence the conditions are reversed.

7. A tactical body once thrown into a firing line on the offensive cannot be relieved, its remnants, great and small, will remain in the firing line to the end of the action.

5. The intermixture of tactical units, which, under the present condition of warfare, occurs more frequently and on a larger scale than formerly, is an inevitable evil. All that can be done is to put it off to as late a stage of the battle as possible, by means of tactical dispositions, and to minimize its bad effect by training and discipline.

9. The importance of the company as a battle unit is much increased, and pari passu the importance of the captain as a commander.

The Prussian company column is the normal formation.

10. The best organization for the battalion is in four companies from 200 to 250 men strong.

11. Good infantry well posted cannot be dislodged by a mere frontal attack unless the assailants are in very superior numbers and even then success is uncertain and only to be purchased at an enormous sacrifice. Hence, whenever possible, an attack on one or both flanks must be combined with the frontal attack.

16. In order to get its full value out of its present armament, infantry should be trained to firing by companies and smaller bodies at long ranges but such firing should only be by word of command, and the utmost care must be taken to prevent waste of ammunition.

Long range firing will generally be used with more effect by troops on the defensive than the offensive. Rapidity of fire, which is one of the chief qualities of the breech loader and more especially of the repeating rifle, should only be taken advantage of at close quarters, and for very short periods. Deliberate, independent firing is that most commonly used.

Before discussing the principles above mentioned let us take a general look at the form for combat as laid down in the present tactics of France and Germany.

Two years ago the French Government issued a new manual of instructions for combat. The guiding principles of these revised tactics may be gathered from the opening paragraphs :

1. The offensive alone admits of decisive results the following principle expressed in the present regulations should serve as a basis for military education and a guide in the exercises and maneuvres.

2. To increase in the infantry aptitude for the offensive combat.

To increase the power of fire by reducing the front of combat and giving a greater density to the firing line or chain.

To give to the disposition for combat a lively and vigorous character by closing up the supports and reserves and so produce an incessant push towards the firing line.

(To be continued.)

INFANTRY UNDER GERMAN ARTILLERY FIRE.

BATTLE FORMATIONS AND MARCH TO THE ENEMY'S LINE.

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NECESSITY OF KEEPING INFORMED ON THE METHODS OF ARTILLERY FIRE.

French officers are, generally speaking, great specialists, the majority of them making the mistake of confining themselves to their particular arm of the service. This spirit is not unlikely due to the difference in the origins and also in great measure to the constitutions of the garrisons—a constitution which rarely permits a mingling of the different arms in practical drills. Then too, our maneuver regulations in the study of combat methods, which they separate into successive and well defined phases, do not ordinarily contemplate anything but a struggle between adversaries of the same arm.

From this it results that many young officers learn only the tactical methods of their own arm. For them the battles of the future would have the following aspects: first,—a period of furious galloping and a noisy clash of steel produced by the masses of cavalry dashing together in front of the belligerent armies and then disappearing to go whirling in the distance upon the flanks; then the thunder of two long lines of artillery engaging each other in an interminable cannonade; finally that phase which Article 129 of our field service designates as fatiguing and laborious, in which infantry troops, preceded by chains growing denser and denser, progressively advance from obstacle to obstacle and finally decide the victory.

This is a conception as erroneous as it is dangerous. Upon the field of battle the three arms will have to meet adversaries of the three arms. The common success will come from their harmonious co-operation, mutual assistance and habit of acting in concert. Hence, the necessity of frequently mingling the different arms on every-day occasions in such a manner as to produce among them under all circumstances practical and, as it were, instinctive combinations.

Hence, also, the necessity for us infantrymen to become especially acquainted with the new artillery, which, in a few years has undergone such progress and to ascertain as exactly as possible its effects at all ranges, long and short as well as medium.

General Bonnal tells us that a body of infantry dispersed by a severe and unexpected artillery fire, even for a moment and at a long range, is a body whose morale is strongly shaken and no great effort is any longer to be expected from it, for of such it is incapable.

So much for long ranges and as to short ones it seems to us that it would be a mistake to admit that infantry moving on to the decisive attack has nothing more to fear from the hostile artillery fire ; this artillery, in fact, is only partly destroyed. If a few batteries can still fire, they will certainly refrain from the artillery duel when the decisive attack is made and will direct their fire upon this new and much more important objective. On the other hand, other batteries, at first silenced, may at this moment have recovered and they too will enter the battle again and act in such a manner as to still produce considerable effect.

During almost the entire battle the infantry troops will therefore be exposed to artillery fire and they will have to cross the considerable distances of three or four thousand meters either under this fire or menaced thereby.

In general, artillery officers, with a conviction proving confidence in their guns, say that nothing can resist their fire. This opinion is, however, based upon experiments made on the practice grounds, where no matter what be done, all the elements of fire and the ground are known, and during these experiments it is impossible to take into account the movements in various directions which would be made by troops upon the battlefield.

Often also, the conviction we speak of is very largely based upon purely theoretical studies in which the action is supposed to take place upon a terrain absolutely flat like a billiard table. Under these conditions there is nothing to fear in regulating the fire, nothing to obstruct the view, no shelter to mask the troops and insure them protection for a more or less extended period ; finally, the behavior of the guns is the same for every piece, the fuzes and projectiles are perfect in construction, and all the shots are well placed.

In real warfare the case is quite different. Without taking into consideration the uncertainty of the cadres, which are sometimes improvised, the weariness of the cannoneers and the natural excitement of everybody, the artillery, when in battle, knows nothing of the terrain except what can actually be seen ; besides it is in almost complete ignorance of the moment when the enemy will appear or the manner in which he will present himself. The obstacles on the surface of the ground are as numerous as varied, and an apparently insignificant undulation frequently affords cover to entire battalions. These undulations are met with almost everywhere. Even at Saint-Privat the ground gone over by the infantry of the Prussian guard on the 18th of August, 1870, is not like a billiard table. In the neighborhood of 600 meters to the west of Roncourt and Saint Privat there is a slight fall in the terrain which served as a shelter for the first and fourth brigades of the guard. From this fall in the ground and perpendicular to it, there extend toward Saint-Ail and Sainte-Marie small valley like depressions which might have been utilized by these two brigades in their rash and premature march against the French positions.

The question of marching under artillery fire is therefore a very complex one. This is why our infantry regulations, not believing themselves able to settle said question speak of it only in a rather vague manner. Besides, it would be rash to attempt to make rules of which the first action would perhaps demonstrate the inanity. The point of prime importance is to render the troops supple and to train all the commanding officers to assume by their own initiative and quickly, and guided by their experience and judgment, formations adapted to the conditions and to the terrain. For this purpose it is necessary to know the fire methods of the adversary whom it may be necessary to contend with and it is from this point of view that the present study has been prepared.

There can not, however, be anything absolute about these conclusions, as the knowledge of the adversary's fire affords information only on one simple point, viz., the relative value of the various formations under his fire; whereas, the tactical employment of the troops being determined by the conduct of the action itself, still remains the all-important consideration.

THE MODEL '96 FIELD GUN OF THE GERMANS.

The German field artillery was equipped in 1896 with a rapid-fire gun of a model called F. K. '96 (Field gun '96). which constitutes the greater part of the field matériel (21 batteries out of 24 in a normal army corps). The guns are ornamented on the exterior by carvings and mottoes *pro gloria et patria, ultimo ratio regis.* This piece is in appearance very similar to our 75 mm cannon, although, according to the judgment of all artillerymen, it is notably inferior to the latter. The caliber is 77 mm and the charge and projectile are separate, which thus prolongs the time of loading a little. The sight is graduated to 5,000 meters.

The piece fires two kinds of projectiles, each weighing in the neighborhood of six and one-half kilograms; one is the *Granate* or high explosive shell employed in curved fire against obstacles or troops strongly defiled. The efficacy of this projectile can not be counted upon unless it bursts in the immediate vicinity of the target. The other projectile is shrapnel, having an excellent fuse and holding 300 bullets each about 12 mm in diameter. These bullets are projected in a full conical sheaf, the opening of which is an angle of about sixteen degrees, and the trace upon the ground, when the burst takes place at the proper height, is a very elongated elipse with a major axis of about 300 meters and a minor axis of 25 meters.

In this study we will consider only the shrapnel which, after all, is the true projectile of battle.

The accuracy of the F. K. '96 is such that the total shots fall within a rectangle 150 meters long by 50 wide, and half of them in a rectangle 38 by 12. There are four charges contained in each of the ammunition baskets, thus greatly facilitating their transportation. There are nine of these baskets in each chest, and as the battery has six caissons (of which two are filled with high-explosive shell) it follows that each battery has a direct supply of 780 rounds, or 130 per gun, without being compelled to have recourse to the light ammunition columns.

The battery is accompanied upon the firing line by three caissons which are unhitched a few paces to the rear of the guns. The latter, separated according to regulations by intervals of about sixteen meters, are served by a non-commissioned officer and five cannoneers whose number may be reduced to two, but, of course, to the detriment of the rapidity of action. During the firing all the teams are sheltered, the personnel seeking shelter as much as possible, either by kneeling around the piece or by hiding themselves under the caisson or behind the sacks of the cannoneers.

MANUAL OF FIRE.

These brief notes having been given, we will now examine the firing methods as prescribed in the new manual of August 10, 1899. This manual does not merely contain rules for ranging and for the conduct of the fire, but it also treats of the instruction of the gunners, of the judging of distances and of the execution of battle fire. Faithful to the doctrine which prevails in the preparation of all regulations of the German army, and anxious above all for the instruction of the reserves, the new firing manual does not modify the methods in use before the adoption of the rapid-fire gun. This latter, as it takes pains to announce, is only a quick-loading gun.

EMPLOYMENT OF THE DIFFERENT KINDS OF FIRE.

RAPIDITY OF FIRE.

The German artillery admits three standard rates of fire:

1st. Slow fire, used in regulating the fire, the rapidity of which depends on the facilities for observation only.

2nd. Ordinary fire, of from four to six shots per minute per battery of six pieces.

3rd. Rapid fire, which may go as high as fifty shots per minute (about eight series of six shots each.)

According to the manual, this kind of fire should be employed only to take advantage of some transitory circumstance of the battle, or when it is essential to obtain the maximum effect within a limited period of time against a moving target or a fixed one at a distance of less than 1500 meters. The proper appreciation of the tactical situation alone can serve as a basis for choosing the rate of fire to be employed. It is wise to alternate rapid fire with ordinary fire in such a manner as to ascertain the effects produced, thus avoiding too extravagant a consumption of ammunition.

Time-fuse fire, with the interval between the point of burst to the target varying from 30 to 150 meters, is recommended even for short distances. It is only at distances under 300 meters that the regulations prescribe the employment of rapid fire with percussion shell, aiming point blank through the rear sight notch and the front sight.

There are four conditions under which time-fuse fire should be employed:

1st. When the ground occupied by the enemy is soft or marshy.

2nd. When the enemy is in the woods or when crossing high growing crops or underbrush, for then the percussion shells, if they burst, could be observed only with difficulty.

3rd. At great distances, for the angle of fall being great, the percussion shell would sink into the ground where its fragments would remain buried when it bursts.

4th. For the same reason where the ground rises toward the position occupied by the enemy.

REGULATING THE FIRE.

The rules adopted for regulating the fire contemplate the following three principal cases:

1st. Fire upon a fixed visible target.
2nd. Fire upon an invisible target.
3rd. Fire upon a movable target.

Fire upon a fixed visible target. Regulating the fire consists in finding out the difference between the long and short shot, that is,—inclosing the target between two percussion shots one of which is short and the other beyond; the distance between them being fifty meters if it is desired to continue with percussion shell fire; one hundred meters if to continue with time-fuse fire at a range above 1,500 meters and finally, 200 meters if time is pressing or if the distance is less than 1,500 meters. The distance of 200 meters between the long and short shot is called the broad fork while the distance of 50 meters is called the narrow fork.

In a series of six percussion shots fired with the mean elevation of the fork, the regulation of the fire is considered to be exact if two shots at the least and four at the most are short.

In fuse-fire, the height of bursting is considered regulated when out of six fuse shots but one of them is beyond.

It is, moreover, so important to realize just what regulating the fire really means that it is well to pause a moment over this question and to treat it upon the basis of examples taken in the most general of cases, viz., fire against an unsheltered and immobile body of troops at more than 1,500 meters: The estimate of the distance made by the Captain by eye is 1,800 meters; the first shot fired at an elevation corresponding to this distance is clearly observed and is short; the elevation is increased by 200 meters and the second shot fired with the elevation at 2,000 meters is still short; the third with the sight at 2,200 meters seems to fall beyond; this is confirmed by the fourth shot; the target is then between 2,000 and 2,200 meters; a fifth shot fired at the intermediate elevation, 2,100 meters, is short, and the sixth fired with the elevation of the fourth shot, 2,200 meters, is beyond.

The battery then has the fork of 100 meters sufficiently accurately to pass to time-fuse fire; the target is then divided between the six pieces. The fuse is set at 2,100 meters, and a first series of six shots is fired at the 2,100 meter elevation, which corresponds to the inferior limit of the fork.

If two shells are exploded by percussion of time-fuse below the target, it shows that the interval between the point of burst and the target is too short, and the trajectory is increased by elevating the sight one division. And now a new series of six shots is fired and, if the bursting then takes place at the right height, an effective fire is executed by firing alternately by series at the inferior and superior limits of the fork, with the rapidity of fire dictated by the tactical situation of the moment.

If the target had been at a distance of less than 1,500 meters, the effective fire could have been taken up after the fourth percussion shot, that is to say, as soon as the broad fork of 200 meters had been found. In this case, there would have been executed, using fuse-shell fire, a sort of progressive fire upon the two limits of the fork and upon the intermediate distance.

In all that precedes, we have admitted that the aim was always correct and all the shots were well observed ; but these conditions are rarely realized and there are two kinds of causes for error which retard the regulation of the fire, but which can not prevent it from being eventually accomplished with certainty when the target is fixed and clearly visible.

Fire at an invisible target.—The captain begins by finding the range as above, but by taking in place of the real objective which is invisible, a perfectly distinct one—either the crest of the mass obstructing the view (in this case the unobserved percussion shots are considered as beyond, which may be a cause of error) or, what is better, the captain selects some conspicuous reference point, either to the right or left of the objective. He then gives to the pieces the proper lateral sight allowance to deliver shots in the direction of this objective and strikes the ground with series of six shots each, graduated by intervals of 100 meters. As it is impossible to observe the results, this fire is very uncertain and this case is one of the rare ones in which the manual recommends the high-explosive shell in spite of the small effective radius of this projectile.

Fire upon a moving target.—1st. When the target is approaching the battery. The essential principle of firing upon a moving target is to enclose by a percussion fire the objective within a fork whose deviation depends upon the nature of the target and the rapidity with which this target is moving, being 200 meters for infantry, 400 meters for artillery and cavalry at a trot, and 600 meters for cavalry moving at a gallop. This fork obtained, fuse-fire is taken up, diminishing the distance of the short shot by 100, 200 or 300 meters, according to the rapidity of motion of the objective, and effective fire is executed as rapidly as possible and by series until a shot beyond is observed. The conclusion is then drawn that the target has arrived in front of the line of the points of fall, and the guns that are loaded are immediately fired in a volley. Then the fire is brought 200, 400 and 600 meters on this side of the objective and the operation that has just been explained is continued.

2nd. When the target is receding from the battery. In this case the fire is commenced by forming with percussion shell a fork of 200, 400 or 600 meters in length, according to the nature and rate of march of the target. Then resort is had to fuse-fire, at the longer range, to ordinary fire, and then to rapid fire as soon as any results or a short shot are observed. When the target seems to have gone out of the zone of efficient fire, the distance is increased according to the rapidity of motion of the target, consequently by 200 meters against infantry, by 400 against mounted troops at a trot, and by 600 against cavalry at a gallop.

3rd. When the target changes from halt to motion and the reverse. When a target, during whose immobility a fuse-fire is continued, increasing or diminishing the elevation by an amount corresponding to the speed of the target. When the target stops, the fire is continued as against a fixed target, giving, however, to the fire as great a rapidity as possible, in order to utilize its full destructive power during this period of halting.

4th. When the target changes position nearly parallel to the battery. If the target moves perpendicularly or obliquely to the line of fire, the preceding methods are employed, but the correction of the lateral shift is adapted to the direction of the movement.

Fire upon marked zones.—Whatever may be the nature of the movement of the target, the German artillery makes much use of fire upon marked zones, which the regulations advocate as being the true "fire of battle." This fire is executed in the following manner : As soon as the artillery has been placed in position, measurement is made of the distance separating it from all the notable points of the terrain, and especially from those which might become the points where the hostile troops would be obliged to pass ; this is done either with range-finders, or by a systematic range-finding operation, or, better still, with the map.

As soon as a body of troops appears in the vicinity of these points, it is assailed by a rapid fuse-fire which follows it in series graduated at 100 meters if it is moving at a slow rate of speed, or at 200, 400 and 600 meters, according to its apparent rapidity of movement.

This kind of fire will be more efficacious and will produce greater moral effect if it is done by surprise and with great accuracy.

GENERAL METHOD OF EMPLOYING THE GERMAN ARTILLERY.

In conclusion, and whatever may be the method of regulating the fire adopted by the Germans, they endeavor to utilize the rapidity of the effects of their guns, as well as their destructive power, much more than they do their great range.

For their effective fire they seem to have adopted, as characteristic of the employment of shrapnel, the method by "Squalls" (sweeping fire), without making use of the French expression implying this term. As soon as their opponents uncover themselves, the Germans become lavish with their ammunition, which up to this point they have economized with a generous avarice, for the manual is continually recommending to fire but little.

They make it a point to utilize the terrain in such a manner as to mask the batteries and protect the troops. Finally, they avoid fires at great range and enjoin batteries menaced by a direct attack to remain in their positions and to continue the fire until the last moment. Acting thus, they appear to have appropriated for the artillery the famous precept of Marshall Bugeaud for infantry fire.

As to the tactics of the German field artillery, the instructions for battle, which show the dominant ideas in a few pages, sum it up in the following manner:

"To open the way to the infantry and to aid it always and everywhere in the accomplishment of its tasks, is the role of the artillery. To endeavor by all means to hold the important points of the enemy's line as soon as possible under a crushing fire, such is the general aim of its tactics."

All that we have just stated is confirmed in the address held on the 12th of January, 1899, by General von Gossler, the Minister of War of Prussia, in which he demands of the Reichstag the necessary appropriation for a new artillery organization. But, after having boasted of the ballistic qualities of the Model '96 field gun, General von Gossler remarked that the very flatness of its trajectory increased the difficulty of striking an enemy ever so slightly sheltered, and that it must be expected an enemy would seek to escape the fire by a reasonable utilization of natural or artificial cover where the pieces are located.

This leads us to look into the best methods for infantry to escape, partially at least, the formidable effects of artillery fire.

(To be continued.)

EXPERIMENTS IN ILLUSTRATION OF THE TOP-MOTION OF ROTATING OBLONG PROJECTILES.

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(Continued.)

EXPERIMENTAL DETERMINATION OF THE MOMENTS OF MODEL AND ACTUAL PROJECTILES.

In the theoretical investigations of the motion of rotating oblong projectiles, it is important to know the moments of inertia about their geometrical and transverse axes. A knowledge of these moments of inertia is also necessary for the comparison which will have to be made between the phenomena of gyroscopes, previously described, and those of projectiles moving freely.

With this objebt in view, I have experimentally determined a few such moments of inertia, and am influenced to publish the results thus obtained the more, as similar experimental determinations are nowhere else quoted.

The models or projectiles were suspended by bifilar-suspension and set to oscillating. The suspension wires, of two meters length, were placed very close together and had their lower ends attached to thin plates which carried the suspension hooks and a small mirror.

The transits through the positions of equilibrium during the oscillations, were observed by means of a telescope and a scale (Poggendorff's reading mirror) and were recorded, by means of a very simple registering apparatus, upon a drum covered with sooted paper and moved by clock work. A second and quite similar registering apparates, recorded, at the same time, the seconds; for this purpose, a Lamont quicksilver contact was adjusted to the seconds pendulum of a clock.

Both thread suspensions employed gave moments nearly independent of the load. This may be partly due to the fact that the distance between the threads was very small as compared to their length, and to the further fact that the torsion of the wires essentially predominated.

The first experiments were conducted with model I. The inner suspension ring I of the apparatus, was caused to oscillate first by itself, then in combination with the model; the axis of the model was vertical in the first and horizontal in the second series of oscillations of the combination.

The moment of inertia of the ring was calculated by the formula:

$$J = \frac{1}{12} M \left[h^2 + \frac{3}{4} (d_a^2 + d_i^2) \right],$$

in which the mass .... $M = 243.01$ *grammes*,
the external diameter .... $d_a = 22.64$ *cm.*
the internal diameter .... $d_i = 21.24$ *cm.*
and the thickness .... $h = 0.59$ *cm.*

Substituting these values in the above equation we obtain

$$J = 14643.95 \ g' \ cm^2.$$

The time of oscillation of the ring alone was found to be $\tau = 6.709$ seconds.

The mass of the model mounted on its axis was $734.28 \ g$; the times of oscillation of the model and ring combined were found to be:

For model axis vertical .... $\tau' = 7.842$ sec.
For model axis horizontal .... $\tau'' = 8.754$ sec.

Under the supposition that the moment Δ of the bifilar-suspension, is independent of the weight considered, as shown by previous experiments, we readily obtain, from the formulas for the times of oscillation about a vertical axis, when we denote by J, the moment of inertia of the ring, by A, the moment of inertia of the model about its geometrical axis and by B, its moment of inertia about a transverse axis through its center of gravity:

$$\tau = \pi \sqrt{\frac{J}{\Delta}}; \quad \tau' = \pi \sqrt{\frac{A+J}{\Delta}}, \text{ and } \tau'' = \pi \sqrt{\frac{B+J}{\Delta}},$$

from which

$$A = \frac{\tau'^2 - \tau^2}{\tau^2} \cdot J, \; B = \frac{\tau''^2 - \tau^2}{\tau^2} \cdot J \text{ and } \Delta = \frac{\pi^2}{\tau'^2}(A+J) = \frac{\pi^2}{\tau''^2}(B+J).$$

Substituting for J, τ' and τ'' their value as found above, we have

$$A = 4894.9 \ g' \ \text{cm}^2, \; B = 9703.85 \ g' \ \text{cm}^2, \; \Delta = 3135.79 \ g' \ \text{cm}^2 \ \text{sec}^{-2}$$
$$\text{and } B:A = 1.9824.$$

The times of oscillation of model II, whose mass was $808.68 \ g$, when set in the ring indicated above, were

For model axis vertical .... $\tau' = 7.777$ sec.
For model axis horizontal .... $\tau'' = 12.080$ sec.

Substituting these values in the preceding formulas, we obtain

$$A = 4572.40\, g'\ \text{cm}^2,\ B = 31720.00\, g'\ \text{cm}^2,\ \Delta = 3135.79\, g'\ \text{cm}'\ \text{sec}^{-2}$$
$$\text{and } B : A = 6.9373.$$

The model of the original Magnus apparatus of the Physical Institute of the Vienna University was kindly placed at my disposal by *Hofrath* Boltzman, but not desiring to remove the same from its suspension ring, the times of oscillation of the combination only could be determined.

The mass of the combination was $359.70\, g$; the mass of the ring, calculated from the following elements, viz., $d_a = 11.55$ cm, $d_i = 10.47$ cm, $h = 0.45$ cm, and specific gravity $s = 8.6$, was found to be $72.3\, g$. From this mass the moment of inertia of the ring was found to be $J = 1109\, g'$ cm². The value of Δ was assumed to be the same as previously determined, viz.: $3135.79\, g'$ cm² sec⁻².

The observed times of oscillation were

$$\tau' = 2.546 \text{ sec.},\quad \tau'' = 3.335 \text{ sec.},$$

from which we obtain

$$A = 950\, g'\ \text{cm}^2,\ B = 2425\, g'\ \text{cm}^2 \text{ and } B : A = 2.533.$$

In the original Magnus apparatus, as also in that by me constructed, the value of the moment of inertia of the ring in which the model is suspended lies between those of the moments of inertia of the model about its geometrical and transverse axes.

The Poinsot motion of such a gyroscopically suspended model, owing to the non-rotation of the masses of the rings, is noticeably different from that of a body perfectly free to move.

The determination of the absolute values of the moments of inertia for actual projectiles was made for a 9 cm. shell M. 1875 and for a 4 pound (8 cm.) shell M. 1863.

The 9 cm. shell M. 1875 was filled with sand and weighed 6.36 kg., the weight of the service projectile. The fuze hole, however, was closed with a wooden screw plug in which a suspension stirrup had been inserted.

The diameter of the bore was 8.65 mm., its length 24.25 cm.; the projectile was three calibers in length.

This projectile was caused to swing by a suspension B, consisting of two, 1½ mm., German silver wires, 2 mm. apart, from which it could be suspended, by means of its suspension stirrup, so as to swing about its geometrical axis. To determine the time of oscillation about its traverse axis, a narrow band of thin zinc was secured to it behind the second of its front rifling bands; this band has hooks soldered to it by means of which the projectile could be attached to the suspension B.

The center of gravity lay slightly over 9 cm. from the base of the projectile.

The times of oscillation were found to be

For the vertical axis .... $\tau' = 2.990$ sec.,
For the horizontal axis .... $\tau'' = 5.803$ sec.

The moments of inertia being proportional to the squares of the times of oscillation, we have

$$B : A = \frac{\tau''^2}{\tau'^2} = \frac{33.6748}{8.9400} = 3.7667.$$

In order to investigate the accuracy of this value and to find the absolute values of the moments of inertia, a parallelepipedal steel rod was fixed horizontally to the mirror carrier of the bifilar-suspension, so that its center fell between the suspension wires; its moment of inertia was calculated from the data, which were as follows:

Mass .... $M = 249.74\ g$,
Length .... $l = 67.85$ cm,
Width .... $b = 0.51$ cm,
Height (thickness) .... $h = 0.95$ cm.

From these was obtained

$$J_0 = \tfrac{1}{12} M (l^2 + b^2) = 95814.5\ g\ \text{cm}^2.$$

This rod had two file marks near its ends symmetrically located with reference to its center and separated by a distance $2\,d = 66.10$ cm. At these points, two accurately cylindrical brass weights, with right angled hooks screwed into their centers, could be hung, by means of thin wires, and thus the moment of inertia of the rod be increased by a calculable quantity.

The data for this calculation were as follows:

Mass of one weight .... $M = 259.5\ g$
Cylinder radius .... $r = 1.42$ cm.
Mass of one suspension wire .... $m = 0.146\ g$.

From these the moment of inertia to be added was found to be,

$$J_g = 2\,[\tfrac{1}{2} M r + (M + m)\, d^2] = 567745\ g'\ \text{cm}^2.$$

The times of oscillation about the geometrical axis were found to be

For the projectile and rod .... $\tau' = 4.69$ sec.,
For the projectile, rod and weight.. $\tau'' = 10.01$ sec.

We also have

$$\tau' = \pi \sqrt{\frac{A + J_0}{J}} \text{ and } \tau'' = \pi \sqrt{\frac{A + J_0 + J_g}{J}}$$

from which we readily obtain

$$A = J_g \cdot \frac{\tau'^2}{\tau'^2 - \tau^2} - J_0 \text{ and } \text{⅃} = \frac{\pi^2}{\tau'^2}(A + J_0).$$

From these formulas we deduce at once

$$A \underset{\cdot}{=} 63872\, g' \text{ cm}^2 \text{ and } \text{⅃} = 71322.2\, g' \text{ cm}^2 \text{ sec}^{-2}.$$

The same experiments, conducted with the projectile axis suspended horizontally, gives,

For projectile and rod.............................. $\tau' = 6.80$ sec.,
For projectile, rod and weights....... $\tau'' = 11.15$ sec.,

from which we readily obtain

$$B = 240401\, g' \text{ cm}^2 \text{ and } \text{⅃} = 71433\, g' \text{ cm}^2 \text{ sec}^{-2}.$$

The difficulty of suspending the projectile so that its axis shall be exactly horizontal, is expressed by a difference of more than 1 % in the two values of ⅃.

The ratio of the moments of inertia, $B : A = 3.7637$, agrees with the value previously found to within 0.08%.

We see from the above, that the moment of inertia of a fuzeless 9 cm. shell M. 1875, about a transverse axis through its center of gravity, is 3.765 times as great as that about its geometrical axis.

The determination of the moments of inertia of a 4 pound shell M. 1863, resulted less favorably than in the previously conducted experiments owing to the greater difficulty of attaining an accurate adjustment of the projectile, because of its wedge-shaped bourrelet, without undue complication of the apparatus.

The shell was filled with sand and the fuze hole closed with a screw plug, its weight thus filled being 3.66 kg. The diameter of the cylindrical portion of the shell was 8.57 cm., its length two calibers and the length of its core 15.84 cm.

From the oscillation experiments with rod and weights attached, the results obtained were as follows :

$$A = 34481\, g' \text{ cm}^2,\quad \text{⅃} = 71734\, g' \text{ cm}^2 \text{ sec}^{-2},$$
$$B = 86330\, g' \text{ cm}^2,\quad \text{⅃} = 71081\, g' \text{ cm}^2 \text{ sec}_{-}{}^{2}, \text{ and}$$
$$B : A = 2.5037.$$

Another series of experiments under the assumption that $\text{⅃} = 71300$, gave the following values :

$$A = 34281,\quad B = 87735,\quad \text{and } B : A = 2.558,$$

showing thus a difference of two per cent in the value of the two ratios.

EXPERIMENTS WITH THE MAGNUS' GYROSCOPE.

The original Magnus model, when exposed to the air current with its axis slightly inclined, turns its point upward ; the resulting resistance of the air thus acts in front of the center of gravity.

In order to expose the rotating model to an air current of sufficient cross section, Magnus closed the air chest of his ventilator with a metal plate perforated with 484 holes 1mm in diameter. There were thus generated 484 parallel air currents and consequently the current disiributed over a greater surface.

Magnus described the phenomena as follows: "When the axis of the projectile model was placed in the verticle plane through the axis of the air current with its point slightly raised above the horizontal plane through the center of gravity, the point moved slowly sideways, at first in a nearly horizontal direction, then somewhat inclined to the horizontal. If the rotation was right handed the deviation was to the right and vice versa. If the rotation continued long enough for the point to sink below the horizontal, the lateral deviation of the point was again produced."

I have quoted Magnus' report on this experiment in his own words, for the reason that it seems to have been construed as indicating that the projectile, after passing under the horizontal plane, took up a retrograde motion, whereas it was but executing its precessional rotation, in consequence of which it approached the vertical plane passing through its initial position.

As the angular velocity of the model in the Magnus apparatus was quite large compared to the strength of the air current, the precessional motion proceded very slowly and scarcely completed half a revolution before the former died out completely.

The air current in the first experiments with model I of the Austro-Hungarian Technical Military Academy, was produced by means of a large bellows fitted with a broad blast nozzle.

In 1868 a Langen & Wolf, 2 h. p. gas engine, was installed in the Physical Cabinet, to drive a Crompton compound dynamo. The latter was connected with a Schiele centrifugal ventilator of 50 cm. diameter, and a 19 cm. diameter nozzle inserted in the aperture. By this means an air current of sufficient cross section was obtained, having a velocity of from 4 to 5 meters per second.

The three projectile models, previously described, of the gyroscope of the Austro-Hungarian Technical Military Academy, acted precisely as the original Magnus model, i. e., when exposed to an air current with their points slightly inclined upward, the air current turned their points upward. The moment of the wind pressure, in this case, tends to increase the angle between the axis of the projectile and the direction of the wind; the resulting resistance of the air acts, here, in front of the center of gravity.

If the model is exposed to the air current base foremost and inclined to the horizontal, the air current turns the model axis into the direction of the wind, thus diminishing the angle between the projectile axis and the direction of the wind; the resulting resistance of the air acts, here, behind the center of gravity.

The apparatus must be placed as accurately as possible in the medial line of the air current before each experiment. The accurate accomplishment of this object prevents the model from turning about its vertical axis. The neglect of this precaution results in the model executing different parts of its precessional motion in varied time, occasionally also, remaining motionless, owing to the nullification of the different deviating effects.

To demonstrate the deviation of the model caused by the air current, the axis of the model was placed at an angle of 15° to the horizontal and the air current turned on. If the air current was sufficiently strong, model I then generrlly executed three complete, increasing spiral revolutions, about the horizontal, accompanied by a material diminution of its angular velocity. With model II, the cone described by the projectile axis was broadened, so that after a complete revolution the latter was nearly perpendicular to the direction of the air current. Under favorable conditions, model III has made from 4 to 5 complete revolutions about the horizontal before its angular velocity was exhausted.

If the axis of the rotating model be subjected to an impulse it begins to oscillate. These oscillations are very small and of short duration, if the projectile is still rotating very rapidly, and are of greater amplitude and longer duration, if the rotation has already been greatly diminished. In model II. these oscillations with very large amplitudes, are most pronounced and depend on the ratio of the principal movements of inertia of the model.

These oscillations correspond to the vibration, or regular motion of precession, of rotating oblong projectiles which, as previously mentioned, were so clearly seen in pointed shells fired with small charges and high elevations.

Should the rotating models be caused to vibrate while exposed to the air current, the regular precession due to the Poinsot motion would be combined with pseudo-regular precession due to the deviating effect of the resistance of the air.

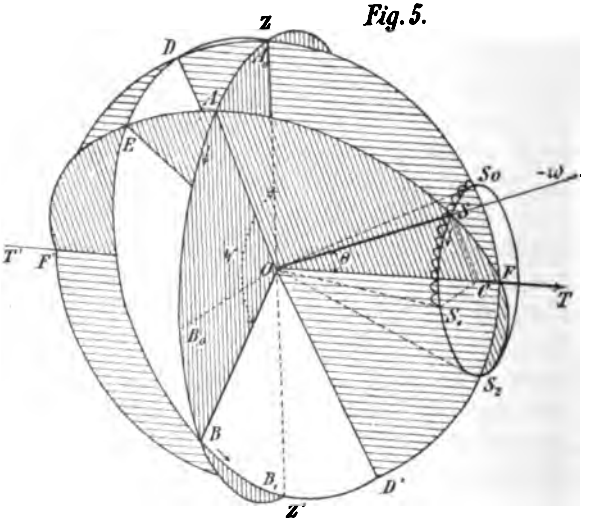
This is the same phenomenon which A. Jellinek has described in his experiments with rifled mortars, previously mentioned, and which was also known to Rutzky.

EXPLANATION OF THE DEVIATION OF ROTATING OBLONG PROJECTILES ACCORDING TO MAGNUS.

The rotation of oblong projectiles under the influence of the moment of resistance of the air is, through the experiments with the Magnus gyroscope, reduced to that motion of a heavy top which has been designated as pseudo-regular precession, i. e., to that motion which a heavy top executes when the end of its axis is below the center of gravity.

The experiments with the Magnus' gyroscope represent the top motion of a projectile for a rectilinear part of the trajectory and for a definite inclination of the projectile axis to the tangent to the trajectory.

Fig. 5.



Let *O*, fig. 5, represent the center of gravity of the projectile, *T' O T*, the rectilinear part of the trajectory, *OS*, the axis of the projectile, assumed coincident with the instantaneous axis of rotation, and *S*, the point of the projectile. Contrary to the usual convention, the rotation will be considered in a direction contrary to that of the motion of the hands of a clock, thus requiring all axes to be taken in the negative direction. With *O* as a center and radius *O S* describe a sphere; let $Z\ A\ B_0\ B\ Z'$ be a vertical plane through the center of gravity of the projectile, *F S A F'* a plane through the axis of the projectile and the horizontal,

$S\ O\ F = \theta$, the angle between the projectile axis and the horizon- and $D\ E\ B\ D'$ an equatorial plane of the projectile. The equatorial plane is perpendicular to $O\ S$ and intersects the vertical plane in the right line $O\ B$, which may be designated as the line of nodes. $B\ O\ Z = \psi$ is the Eulerian angle.

The line of nodes is perpendicular to the horizontal $O\ T$ and to the axis $O\ S$ of the projectile; it is the axis about which the projectile is rotated by the resistance of the air, its direction being here considered negative. Looking from B, S is rotated towards A, thus increasing the angle θ; it is a rotation opposite to that of the hands of a clock.

Should the projectile axis deviate in any direction whatever, the equatorial plane and line of nodes will also deviate, the latter, however, always remaining perpendicular to the horizontal and to the axis $O\ S$.

In fig. 5 it is assumed that the axis of the projectile and the instantaneous axis of rotation are coincident. Designating by A, the moment of inertia about the axis $O\ S$, and by ω the angular velocity about the same axis, the product of $A\ \omega$ is called the moment of momentum. It is the moment of thatimpulssion which could generate, from rest, the instantaneous motion of the projectile model.

The moment of momentum may be laid off on the axis $O\ S$ like the moment of force, except that its direction here is negative. The distance thus obtained is also called the impulse vector, and represents the moment of the impulsion in magnitude and direction. The impulse vector is here drawn on the projectile axis.*

It is also usual to lay off angular velocities as distances upon the axes of rotation, the distances thus laid off representing the angular velocities in direction and magnitude. The angular velocity should here be laid off in the negative direction. These distances are called rotation vectors.

In the figure, the impulse vector, rotation vector and projectile axis coincide for an instant.

The moment of the resistance of the air produces, during a very small increment of time, an increment of the moment of momentum about the axis $O\ B$, i. e., about the line of nodes; this increment, which is a very small impulse vector, must be laid off from O towards B.

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* These and a number of other designations are similar to those employed by Klein and Sommerfeld, in their work "On the Theory of Tops."

Combining the latter impulse vector with that laid off on *O S*, we obtain a resultant impulse vector which falls within the angle *S O B*; the coincidence of the latter with the rotation vector and projectile axis is thus terminated, and as far as the latter is concerned is never again resumed. The rotation vector also wanders from the projectile axis.

Later, a construction will be given by which the new position of the rotating vector may be determined.

The increments of the impulse vector always result about the line of nodes and remain perpendicular to it, so that simply the direction but not the magnitude of the impulse vector is varied. The impulse vector describes the convex surface of a circular cone.

If the angular velocity of the projectile is sufficiently large and the increments of the same about the line of nodes is small, the geometrical axis will always remain very near the impulse vector.

A representation of the broader events of the rotation may be deduced either under the assumption of a so called fizgig (Kugelkreisel) or under the pure geometrical composition of the angular velocity with the increments of the same always perpendicular to it; it is perhaps, hower, more to the purpose, to give, instead of the deduction, a direct image of the event itself. This particular motion has been very clearly illustrated by Poinsot. It may be conceived as the rolling of a cone *T*, the cone of the polhode, which is firmly united to the system, upon a cone *C* fixed in space, the cone of the herpolhode.

In the case assumed, the axis of the projectile belongs to the surface of the circular cone *T*, of very small opening; it will be displaced in the direction of the arrow during the rolling of this cone in the same direction, along the circle S_0 S S_1 S_2 of the circular cone S_0 O S_2, of the herpolhode. The point of the axis will thus describe spherical epicycloids resting on the circle $S_0 S S_1 S_2$.

The progression of the axis in space is called precession and, in the case under consideration, is denoted as progressive pseudo-regular precession.

The wavering which the axis executes in the plane *F S A O* around the whole opening of the cone is called nutation.

Seen from *T*, the point of the model will turn to the right; the resistance of the air will thus act against the left half of the model, and, were the latter easily displaceable towards the right, would be forced in that direction. The free moving projectile is forced to the right out of the plane of the trajectory.

A model having a constant angular velocity, the direction of the air current remaining unchanged, ought to execute several revolutions in consequence of the pseudo-regular precession.

Projectiles moving freely never appear to attain even half a revolution, because the tangent to the trajectory always settles more quickly than the axis of the projestile is capable of following; thus the cone of the herpolhode is not a circular cone as in fig. 5, but an expanding spiral cone upon which rest the dilated epicycloids described by the projectile point.

The deviation to the right of rotating pointed projectiles increases continually, whereas, by the turning of their points to the left, it ought first to diminish and then to result in a deviation to the left.

In case the moment of resistance of the air causes the axis of the projectile to approach the tangent to the trajectory, or the resultant moment of resistance of the air acts behind the center of gravity, the cone of the polhode will roll on the inside of the herpolhode. This case corresponds to a retrograde pseud-regular precession, the projectile point moving in hypocycloids which rest on the inner side of the circle of the herpolhode.

Translated by Captain Frank E. Harris, Artillery Corps.

(To be concluded.)

PROFESSIONAL NOTES.

ARTILLERY MATERIAL.

The Care of Guns, Carriages, and Projectiles.

(Concluded.)

TO BRONZE STEEL.

The surface is cleaned and brought to a good polish. Oil and grease are then removed with a strong alkali and the surface afterwards thoroughly washed and dried in sawdust. An acid mixture is then placed upon the surface to be bronzed and allowed to act for several hours. When the surface is evenly rusted it is vigorously rubbed with a scratch brush till the surface attains a polish. The process is repeated till rust ceases to rise from the application of the acid. The bronzed surface is then washed and polished with the "Gun Polish" mixture previously described.

The following are mixtures for bronzing purposes :—

RUSTING MIXTURE NO. 1.

Alcohol	1½ ounces,
Tincture steel	1½ ounces,
Corrosive sublimate	½ ounce,
Sweet spirit nitre	1½ ounces,
Blue vitriol (sulph. copper)	1½ ounces,
Nitric acid	¼ ounce.

RUSTING MIXTURE NO. 2.

Sulphate copper	½ ounce,
Bichloride mercury	½ ounce,
Tincture iron	2 ounces,
Alcohol	2 ounces,
Water	16 ounces.

Recipe No. 1 is an old Ordnance formula. No. 2 is a mixture that has given satisfaction in practice.

TO REMOVE BRONZING.

Remove oil or oil-polish from surface with hot lye. Then dip in vinegar for half an hour, and wash with water.

The Sighting Rods of the armstrong guns should be bronzed, as, when bright, they reflect too much light and are difficult to keep in a bright condition. The effect of bronzing and polishing them as described is very pleasing.

A VARNISH FOR STEEL.

A substitute for bronzing is as follows :—

White shellac	five (5) parts.
Alcohol	five (5) parts.
Borax	one (1) part.
Water	four (4) parts.
Methylene blue	sufficient.

Dissolve the borax in the water and the shellac in the alcohol. Bring the borax solution to the boil and then add alcoholic solution with constant stirring. Finally add the coloring matter till desired shade is obtained. A very small amount of the coloring matter will suffice. Clean the surface of the steel and remove grease, then apply the colored coating wit a soft clean rag.

COSMIC AND ROSIN MIXTURE.

This is composed of

Dense cosmic	three (3) parts by weight.
Rosin	one (1) part by weight.

The rosin is first melted and the cosmic added and thoroughly stirred. This mixture should be applied hot but care must be taken that it is not so hot as to ruin the brush used. It is safer and better to keep the can of the mixture in a water bath. This will prevent all overheating and keep it sufficiently fluid. In applying it introduce the brush in the bore and rub the bore with backward, twisting strokes. Prepare a barrel of this mixture to have on hand for an emergency.

LEATHER.

There is more or less leather about a gun that requires attention. Fair leather requires washing or it becomes unsightly, and black leather, if neglected, loses its color and becomes "rusty." Leather requires oiling at intervals to prevent its cracking. The leather straps of the breech and muzzle covers are much exposed to the weather and will soon become worthless unless cared for.

OIL FOR LEATHER.

Neatsfoot oil	10 ounces,
Oil turpentine	2 ounces,
Petrolatum	4 ounces,
Lamp black	½ ounce.

Mix lamp black with the turpentine and neatsfoot oil and then add the petrolatum previously melted. For fair leather the lamp black may be omitted.

GLOSSY LEATHER DRESSING.

Water	12 ounces,
Gum Arabic	6 ounces,
Gilding size	2 drams,
Nigrosine	2½ drams,
Glycerine	11 drams,
Oleine (Stearine oil)	1 dram,
Pear oil (for perfume) .....q. s.	8½ drams,
Salycylic acid	1¾ drams.

Make a solution of the first three ingredients and then add the others. The mixture may be boiled down to a paste if desired. Apply with a soft rag. It may be applied to greasy leather and will give a lustre without brushing.

For *Fair Leather* omit the nigrosine substituting a water-soluble analine yellow.

ELUTRIATION.

To obtain a uniform grain in the abraiding powder we desire to use (whether fine or coarse) we elutriate it. The process is as follows:—We have on hand some powdered emery, say flour of emery. We will separate it into, say, three grades of fineness. Provide three jars or tin pails. Number them 1, 2 and 3. Into No. 1 place about an ounce and a half of the emery with a quart of clear water. Thoroughly stir or shake this mixture so that the emery may be thoroughly diffused, then let it settle for five minutes and pour off the liquid into No. 2. Again wash the residue left in No. 1 with a quart of water, let it stand for 5 minutes and pour off the water into No. 2. Repeat this process till at the end of five minutes the water in No. 1 is practically clear. It is evident that the sediment collected in this receptacle is practically uniform. We have now collected in No. 2 a sediment lighter and finer than that left in No. 1. We pour off all but a quart of the water in No. 2 after it has entirely settled and treat the sediment exactly like that in No. 1, pouring off the water, after settling *ten* minutes, into No. 3. We now have a sediment in No. 2 finer than that in No. 1 and in No. 3 we have a still finer sediment.

In making the pomades mentioned below elutriation should be resorted to in all cases if the best results are desired. Whether the pomade is to be fine or coarse *uniformity of grain* is essential.

POMADES.

(1) VIENNA LIME (FOR STEEL).

Stearine	8 to 9 parts,
Mutton tallow	32 to 38 parts,
Colophony	2 to 2½ parts,
Oleine	2 to 2½ parts,
Vienna lime	48 to 60 parts.

Heat the first four ingredients together till thinly liquid, then stir in the Vienna Lime and continue stirring till cool. Keep in *well-closed* tins.

(2) TRIPOLI.

Oleine	40 parts.
Cresine	5 parts,
Light mineral oil (0.87)	20 parts,
Tripoli	40 parts.

Prepare as in No. 1 and keep in boxes.

(3) ROUGE (FOR BRASS).

Stearine	8 to 9 parts,
Mutton suet	32 to 38 parts,
Neatsfoot oil	2 to 2½ parts,
Jeweler's rouge, finest levigated	20 parts,
Calcium carbonate, levigated	40 to 60 parts.

Melt the unguents together. When cool but soft incorporate the powders till the mass is homogenous. Keep in boxes.

(4) EMERY.

Emery	100 parts,
Mutton suet	40 parts,
Oleic acid, crude	40 parts,
Oil of Mirbane q. s. to perfume.	

Proceed as in No. 3. Keep in boxes and number to indicate the grade of emery used.

(5) ROTTEN-STONE (FOR STEEL).

Powdered rotten-stone	1 part.
Petrolatum	1 part.

Mix thoroughly and keep in boxes.

(6)

BRASS POLISHING PASTE.

Powdered rotten-stone	4 ounces,
Oxalic acid	1 ounce,
Ferric oxide	1½ ounces,
Oleic acid	1½ ounces,
Stearic acid	1 ounce,
Paraffin oil	1½ ounces,
Oil of Mirbane (to perfume)	1 drachm.

Melt the stearic acid and oleic acid with gentle heat. Remove from the fire and then incorporate the other ingredients.

(7)

LIQUID POLISH FOR BRASS.

Prepared chalk	2 ounces,
Water of ammonia	2 ounces,
Water enough to make	8 ounces.

Keep in well-corked bottle.

(8)

PASTE POLISH FOR BRASS.

Prepared chalk	8 ounces,
Spirit of turpentine	2 ounces,
Alcohol	1 ounce,
Water of ammonia	2 drachms.

Keep in wide-mouthed bottle.

LACQUER FOR BRASS.

After brass has been thoroughly cleaned and all grease removed the following will preserve its lustre for some time if not subjected to much handling:

Seedlac	90 parts,
Copal	30 parts,
Dragon's blood	1 part,
Alcohol	600 parts.

If the brass is slightly warmed before applying the lacquer the latter will flow better. Use a soft brush. This lacquer is more particularly suited to those parts not handled such as index plates, etc.

PRESERVATIVE OINTMENT.

The following has given excellent satisfaction in practice in preserving steel surfaces from rust. It never should be used near brass and for that reason it is barred about the breech blocks of our sea-coast guns. About a field gun its use is not so restricted.

Metalic mercury	1 pound,
Cosmic	1 pound.

Grind together in a stone or glass mortar. An iron mortar is apt to oxidize the mercury as it cannot be thoroughly cleaned. Test the incorporation by spreading a little of the ointment upon white paper. It should not show metalic mercury to the eye. In practice one need not weigh the ingredients. Place the mercury at hand in the mortar and add the cosmic, a little at a time, with much grinding, till thorough incorporation takes place. Keep in *glass* pots or *wooden* boxes.

PRESERVATIVE COATING FOR BRIGHT STEEL.

When machinery is stored for any considerable length of time the bright parts should be covered with

White Lead Mixture No. 1.

Beeswax	12 ounces,	Circular I.
White lead	16 ounces,	
Tallow	64 ounces.	

Melt the beeswax and stir in the tallow. When thoroughly incorporated add the white lead and stir thoroughly. Use gentle heat. This mixture is applied while warm. Re-heat whenever necessary, and applly with paint brushes.

White Lead Mixture No. 2.

White lead	4 pounds,	Key West.
Lard oil	1 pound,	

This has given satisfaction in practice. A water bath should be used with either of these mixtures. A convenient form is a glue pot or similar improvised device. This will do away with constant re-heating to keep the mixtures fluid.

Practical machinists observe no hard and fast rule regarding the proportions of ingredients in using white lead mixture. The proportions will depend somewhat upon the temperatures, etc., to which it is exposed.

The piston rods of gun carriages, engines, and other exposed bright metal should be covered with this mixture when they have to remain any considerable length of time without attention. It is unexcelled for the bores of guns but is somewhat troublesome to remove for such localities. These white lead mixtures dry on their surface forming a soft crust and perfectly protect the metal beneath. Before applying the metal should be cleaned and freed from grease.

To *remove* the white lead use a stick to scrape off the major part and then wipe with cloths, finishing with benzene or turpentine.

STOPPERS.

It is at times essential to have stoppers for bottles or cans that will not stick or be affected by acids. This may be accomplished by using ordinary bottle corks that have been steeped in *hot petrolatum.* Allow the corks to become thoroughly saturated and then wipe off the surplus.

CANVAS.

Canvas quickly mildews if kept damp or exposed to damp air. Frequent sunning is the only remedy.

TO WATER-PROOF CANVAS.

Boiled linseed oil	15 pounds,
Beeswax	1 pound,
Ground litharge	13 pounds,

Melt the wax and stir in the oil and litharge. Stretch the canvas and apply mixture as a paint. A serviceable water-proof suit or "slicker" may be made by applying the above mixture to a stable frock.

CORDAGE.

Ropes must be stored in a dry place with ample air space. Sunning from time to time is often necessary. Hemp rope is stronger than manila (white) rope. Tarring is resorted to in the case of standing rigging which is exposed to rain to prevent consequent shrinkage. Tarring weakens the rope.

TO REMOVE GREASE FROM CLOTHING.

When one is much about a gun accidental contact of clothing with grease is frequent. The following is recommended :

Cleaning Fluid No. 1.

Saponin	7 parts,
Water	130 parts,
Alcohol	70 parts,
Benzene	1788 parts,
Oil Mirbane (perfume)	5 parts.

Another that is simple but effective is—

Cleaning Fluid No. 2.

Benzene (benzol)	89 parts,
Acetic ether	10 parts,
Pear oil	1 part.

BLACKBOARD.

It is often convenient and at times essential to have a blackboard. The following preparation serves for a coating:

Slating Mixture.

Shellac	8 ounces,
Lamp black	1½ ounces,
Ultramarine	3¼ ounces,
Rotten-stone, powdered	5 ounces,
Pumice stone, powdered	4 ounces,
Alcohol	4 pints.

Dissolve the shellac in the alcohol and then stir in the other ingredients. Apply with a flat brush keeping the mixture thoroughly shaken while applying.

CAPTAIN HAMILTON ROWAN, ARTILLERY CORPS.

RANGE AND POSITION FINDING.

Range Finder for Coast Batteries.

The construction of coast batteries and their application for the defense of coasts constitute a special branch of the science of fortification. The service in coast forts is performed in different states either by marines or by portions of the land army, which latter is the case in Germany, for example, where the so-called foot artillery garrison the coast forts.

The principal targets of these coast batteries are ships, and since the latter are generally in constant motion it is of the greatest importance to determine their exact distance at any moment.

For the determination of this distance the firm of Siemens and Halske had some time ago constructed a range finder for coast defense, in which two observers at the end of a long horizontal base-line simultaneously observed the angle to a ship, and telegraphed it to a central station, where the resulting triangle was reproduced on a reduced scale, and an apparatus was arranged to measure distance.

This required considerable time and labor, and did not fulfill the requirement that the distance must be determined directly by simply directing the telescopes on the target, and automatically communicated to the firing batteries. The problem to be solved, therefore, by the apparatus consisted in transmitting to a battery (B), with indirect fire, the determinations of all data necessary for the conduct of the fire made in a range-finder station (A).

Two solutions of the problem were possible, according as the station A was located on a high or low site; in the one case the height of A above the sea could be used as a base, in the other a horizontal base would have to be used, and a third station (C) consequently made use of.

The following apparatus, invented by Major Braccialini of the Italien army solves the problem by using a horizontal base. It measures, by means of observations outside of the battery, the distance B X, and at the same time the exterior angle X B A. Hence it is called an Exterior-angle Range Finder.

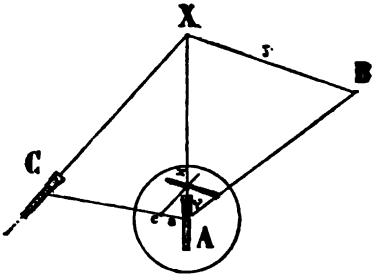

Fig. 1.

The apparatus consists of three separate instruments, namely:

(a) The angle and distance measurer proper, at station A.
(b) The angle measurer at station C.
(c) The angle indicator at the battery (B).

By the use of these instruments, we obtain automatically at station A the constantly changing values of the range $\delta = $ B X and the angle $\varphi = $ A B X; in the battery B the angle $\varphi = $ A B X.

The instruments themselves are shown in figures 2, 3 and 4. At station A the changes in the range δ and the angle φ, due to the motion of the target, can be constantly observed, and automatically transmitted to the battery B. Moreover, the apparatus is so arranged that the battery receives the *corrected* angle. The distance is transmitted either by telephone, or by a special indicator working automatically, giving the following data for firing (see fig. 6):

Attention.	*Charge.*	*Elevation.*	*Deviation.*
	A	7-2-3	2-0

In the principal instrument three parts, A, B and C, are to be distinguished, each turning about a vertical axis (*a*, *b*, *c*) independently. The axis *a* (for the part A) is fixed in position. The axis *b* (for the part B) receives, in setting it up, an excentricity of $a\,b = \frac{1}{50000}$ of the distance A B, Fig. 1, and the axis *c* (for the very light part C) receives an excentricity of $a\,c = \frac{1}{50000}$ of the distance A C, Fig. 1. In this way three vertical axes are obtained, which, in horizontal projection give a triangle *a b c*, similar to the triangle A B C in Fig. 1, in the proportion

$$a\,b\,c : \text{A B C} :: 1 : 50{,}000.$$

The part A also carries a horizontal arm in which the telescope, the finder N, may be moved forward and backward in the direction of the target. The optical axis of the finder lies in the vertical plane passing through the vertical axis *a* of the instrument. In the same plane lies also the optical axis of the observing telescope M (Fig. 2), which is fastened to the part A and turns vertically. The part B, lying within and not visible in the figure, is turned by the handles R, one of which must always be in the hand of the person manipulating the finder. This part contains a glass scale in $\frac{1}{5}$ millimeters, the zero being on the axis *b*. The part C is connected electrically with the angle measurer (Fig. 3); its alidade H (Diopter) turns on the axis *c*, so that it is always parallel with C X (Fig. 1).

The electrical transmission takes place by an improved telegraph system, similar to the Gray telautograph. No matter how rapidly the angle measurer is turned (as much as 60° a minute, which is hardly possible in practice, since no ship can move fast enough to require this), the direction of the alidade remains parallel with that of the angle measurer, and the glass scale constantly gives the direction of C X, to within at least 1°.

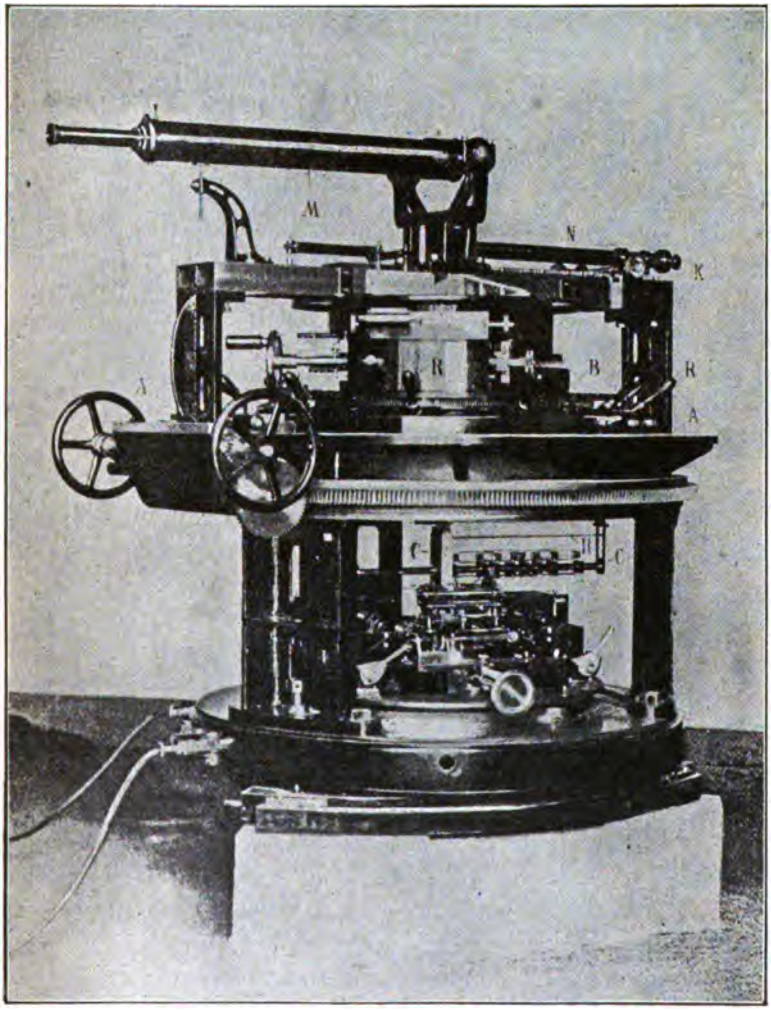

Fig. 2.

The finder N (Fig. 2) has at the objective end a prism, by which the parts within the instrument may be seen. Its optical axis, instead of being indicated by cross-hairs, is marked by a small circle. Now, if the finder be directed on the center of the base and then pushed forward in its jacket till the line on the glass scale bisects the circle in the finder (optical axis), the point x, lying similarly to the target X, will be in the center of this circle. The pushing forward of the finders proceeds in the reduction ratio of 1:50,000, and the distance thus obtained can then be read off on a special scale.

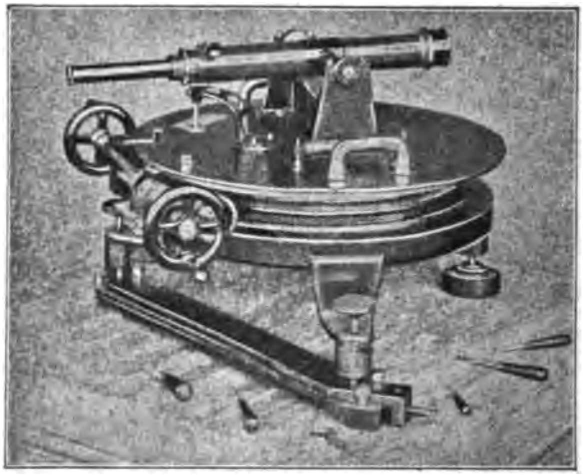

Fig. 3.

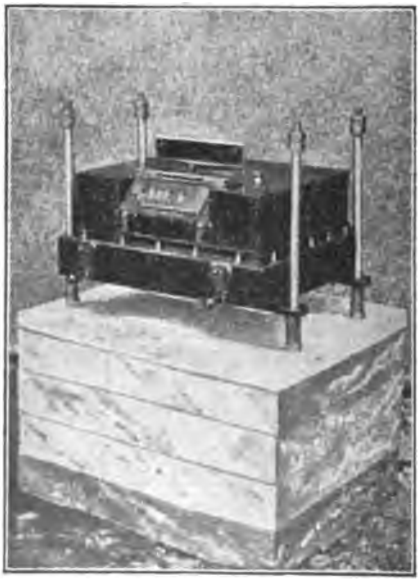

Fig. 4.

The observer at the finder, therefore, pushes the latter forward with the right hand, till the little circle in the finder appears to be bisected by the line; at the same time he turns with the left hand at the handles R, bringing the scale in $\frac{1}{5}$ millimeters in the field of the finder. When the axis of this scale cuts the circle the distance B X (Fig. 1) is read off on the scale. A second observer turns the large observing telescope, following the target uninterruptedly, while a third observer in station C keeps the telescope of the angle-measurer also on the target and follows its movements.

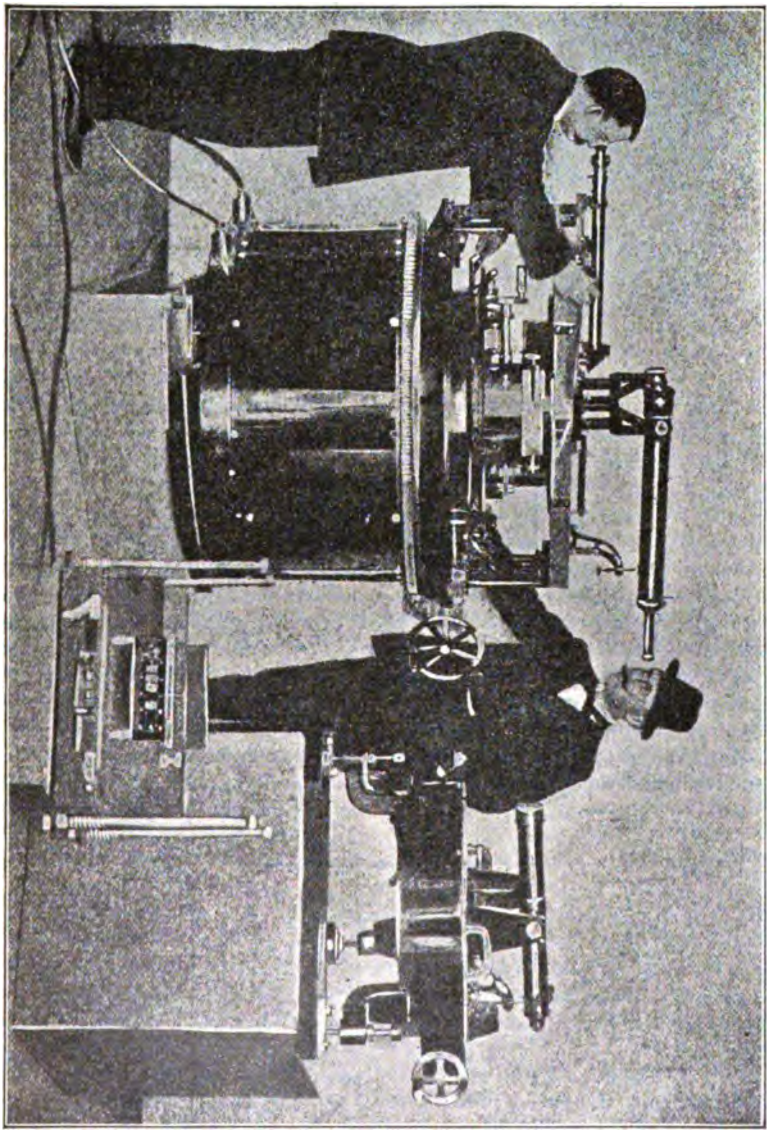

Fig. 5.

In Fig. 5 the two observers are shown at the angle and distance measurer of station A.

In the principal station A we have, therefore, the revolving scale, the direction of which makes at every instant, with the direction A B, the angle $\varphi =$ A B X. This angle can then be read off not only on an indicator in station A,

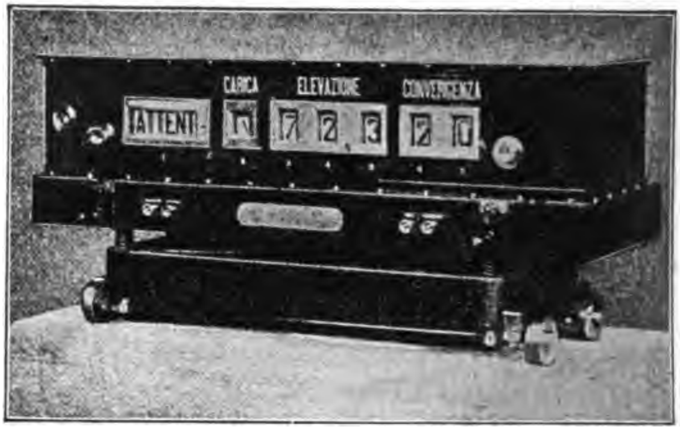

Fig. 6.

but also, by electric transmission, on an angle indicator (Fig. 4), in the battery. The separate figures appear in the open spaces thus, for the angle 148° 7′:

1	4	8	■	7

Such an angle indicator is placed placed on the rear of each gun carriage, placing them parallel, so that each gun commander can at any time read off the angle obtained at station A and C. The latest improved apparatus gives azimuth as well range (Fig. 6).

This ingenious apparatus has exited the greatest interest among navy officers as well as the officers of the coast artillery. More detailed information can be obtained from Herrn K. v. Bodenhausen, Unter den Linden 43, Berlin, N. W. 7, Germany. The apparatus has been adopted by Italy, Japan and Argentina, and was tested last November in Pozzuo, near Naples.

—*Kriegstechnische Zeitschrift.*

BOOK REVIEWS.

The Theory and Practice or Military Hygiene by Edward L. Munson, A. M., M. D., Captain, Medical Department, United States Army. New York: William Wood and Co., 1901. Pp. 971.

This work on the important subject of military hygiene is unique in that it covers completely a field which no other single work has ever more than touched upon; it was prepared under the supervison and with the assistance of the Assistant Surgeon-General of the Army, Colonel Charles Smart, who has an international reputation in this special field of work, and was approved by the Surgeon-General of the Army, George M. Sternberg, whose professional labors in sanitary science are also of world-wide knowledge and practically classic in character. With the records of the Army Medical Department at his disposal, and his own experience in the field to supplement previous experiences, the author has had advantages which enabled him to produce what may be considered a summary of the world's best knowledge of the subject, and the standard of reference in the present decade.

The subject is introduced by general considerations on the selection of the recruit, the development of the recruit after he enters the service, and the march in campaign. Under each of these subdivisions many data are given, and much valuable information, not only for the recruiting officer, but also for all officers having charge of troops in barracks, camp or on the march, who may be responsible for their physical condition and training.

The next subjects receiving attention are water and the articles of the ration, and these are discussed in great detail, scientifically and accurately, from all points of view, theoretical and practical, and these chapters should be the special study of all quartermasters, commissaries and medical officers, and in a more general way of all officers, especially post commanders or commanders of detachments in the field.

Clothing and equipment also receive careful attention; the selection of camp sites and the sanitary administration of camps, subjects of vital importance, are very fully treated; and finally posts, barracks and quarters of all kinds, especially as regards ventilation, heating and lighting, are discussed intelligently and thoroughly, leaving nothing to be desired so far as the army officer is concerned.

The latter part of the work is of more general interest, relating to the cleanliness of the soldier, his diseases, and his habits in so far as they affect his efficiency. These are subjects that concern the daily life of every man, and a knowledge of them should be considered essential by every individual. Special chapters are devoted to the hygiene of hot and cold climates and the hygiene of the troop ship.

The work as a whole is essentially scientific in character, but it is at the same time eminently practical. While the general principles of sanitary science are discussed in all its phases, the practical applications to the army as it is are also carefully considered, and after stating the ideally perfect conditions in any case, the practically possible ones to the army are taken up. There are, for illustration, eight plates and nearly four hundred engravings scattered throughout the text, and these are all excellent. The information contained in the book and the data collected constitute in themselves a most valuable addition to the literature of the general subject, the conclusions drawn are reasonable and generally accepted by the world's authorities, and the applications and lessons to be learned are set forth so clearly and strongly that there is no chance for doubt in any case.

The author came to his work well equipped, and he had every opportunity afforded him for carrying out his design. The stupendous labor involved in producing such a compendium of nearly one thousand pages can, however, hardly be appreciated by the layman. Therefore, it is idle to find fault with insignificant points or portions,—the work must be considered as a whole,—and since such works are usually but labor of love, and bring no financial return at all adequate for either the work or the ability spent on them, the critic should approach his subject with a large-minded spirit, considering mainly *what has thus been accomplished for the world.*

Dr. Munson's compendium, based as it is on the world's authorities, and sanctioned by such men as Drs. Sternberg and Smart, not to mention the author's special ability and experience, fitting him so well for his task, as well as his exceptional opportunities, stands as the best and most complete representative of our present knowledge of the subject of military hygiene.

J. P. W.

Smokeless Powder, Nitro-Cellulose, and the Theory of the Cellulose Molecule. John B. Bernadou, Lieutenant, United States Navy. New York: John Wiley & Sons. London: Chapman and Hall, Ltd. 1901. Pp. 200.

Lieutenant Bernadou of the United States Navy, may justly be regarded as the foremost student in this country of the subject of nitro-cellulose smokeless powders, and this work is the result of his studies in this field.

The first chapter is practically a history of the development of ideas as to the chemical constitution of the cellulose molecule from the discovery of nitro-cellulose to include the latest views of Professor Mendeléef, and the three succeeding chapters develop the conceptions on this subject. The author then gives in full three important essays on the nitration of cotton, by the most eminent scientists who have devoted themselves to its study: namely, M. Vielle, Professor D. Mendeléef, and M. Bruley, the second of which Lieutenant Bernadou himself translated from the Russian and presented to the English-speaking world. The work concludes with Lieutenant Bernadou's essay on the development ot smokeless powder, delivered as a lecture before the U. S. Naval War College.

The work as it stands is not only an exhaustive essay on nitro-cellulose smokeless powders, but is also a valuable contribution to the chemistry of cellulose and nitro-cellulose; moreover, it points the way to the future of smokeless powder and the road its development and improvement must follow.

J. P. W.

Die Automobilen fuer schwere Lasten und ihre Bedeutung fuer militaerische Verwendung. Cav. Pietro Mirandoli, Oberstleutnant. Berlin: E. S. Mittler und Sohn. 1901. Pp. 60. Marks 1.25.

The question of automobiles in war is receiving constantly more and more attention, and almost every nation is working at the subject in one way and another. Italy began her work in this branch in 1873, when the first traction engine was put in use there, and has been deeply interested ever since. The present pamphlet is a collection of essays which appeared in the *Rivista di*

Artiglieria e del Genio. They were written by Lieutenant-Colonel Mirandoli, who as an officer of the Italian engineers had ample opportunity to witness traction engines and motor wagons in actual use under all kinds of circumstances, and is competent to pass judgment on their military application.

The first essay was published in 1898, and it is interesting to note that at that time the author would not admit that the automobile had any *military* use. The second, published but two years later, fully recognizes all the worth of this new means of transportation. The third essay givesan account of the late Liverpool trials, and an appendix contains extracts on the use of road engines, taken from the Italian Handbook for the Engineer Officer in war.

The pamphlet is well illustrated and summarizes our present knowledge of the subject in a satisfactory way. J. P. W.

Patrolling in South Africa. By Lieut. C. F. Vander Byl, 16th Lancers. Aldershot: Gale and Polden, Ltd. Ninepence.

A breezy booklet on an all-important subject, based on experiences in the Boer War. It is clear in language, well illustrated, always to the point in its statements, and is above all intensely practical.

After giving hints on the conduct of a patrol, the author gives a few most interesting examples of actual patrols in the field, and closes with some useful remarks on map reading.

It is altogether well worth study by all officers. J. P. W.

Organisation et Composition des Troupes du Genie et de l'Etat-Major de Cette Arme. Lt.-General Brialmont. Liege: Revue de l'Armee Belge. 1901.

This pamphlet is an interesting study of the organization of the engineer troops in the attack and defense of fortifications by the world's greatest authority on fortifications and fortified camps. J. P. W.

Unsere Bilanz: Ein deutsches Soldatenwort an alle ritterlichen Franzosen. Dresden: Wilhelm Baensch. 1901, Pp. 32.

An appeal to call quits between the two great nations, France and Germany. The author has taken great pains to collect data to show that the total number of victories of the two in their various wars is nearly equal, as also the total number of killed and wounded in all their wars.

Primary the essay was written in the interests of permanent peace between the two nations, as well as with a view to cultivating good feeling between their peoples. Incidentally the data regarding the battles are very interesting.

The Blue Book of American Shipping. Cleveland: The Marine Review Publishing Co.

A marine and naval directory of the United States, the sixth annual edition of this valuable and useful work of reference. It is a resumé of naval and merchant ship construction during the past year and also of the progress of the ship-building industry throughout the country. J. P. W.

History of the Military Canteen. Lieut.-Colonel Philip Reade, Inspector General, U. S. V. (Major 4th U. S. Inf'y.). Published by authority of the Hon. the Secretary of War.

This is a publication permitted by the Secretary of War of reports made to the Inspector General of the Army, during the months of September, October and November, 1900, regarding the Regulation Canteen and other canteens presented for trial with reference to their fitness for use in the military service. The reports were made by the author himself and are the result of his own experience, observation and test.

In a pamphlet of 168 pages Colonel Reade gives us an illustrated history of that most important article of a soldier's field equipment, the canteen. It is interesting and instructive. The tests of the various forms of proposed canteens are given in some detail and seem to warrent a fair trial (if not the adoption) of the Lanz aluminum canteen. This latter, in a great variety of forms is much discussed, and a comparison is made between the Regulation tin and the Lanz aluminum canteen, which is greatly in favor of the latter as regards lightness, strength, durability, cleanliness and the capacity to keep the water at a palatable temperature. J. P. W.

BOOK NOTICES.

[These books will be fully *reviewed* as space becomes available.]

Rapport fra Kommissionen af 1901 til Prove af Hurtigskydende Feltskyts. Kristiania: Steen'ske Bogtrykkeri. 1901.

Appendice II alla Teoria delle Travi e dei Lastroni di Cimento Armato Caricati di Pesi. Crescentino Caveglia, Colonnello del Genio. Roma: Enrico Voghera. 1901.

Description of the Hotchkiss 1 Pounder (37 mm.) Automatic Machine Gun. Paris: Hotchkiss et Cie. 1901.

INDEX TO CURRENT ARTILLERY LITERATURE.

[For Abbreviations used in Index see first number of each *volume*.]

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HISTORICAL SKETCH OF THE FORTIFICATIONS OF SAN JUAN, AND THE ENGLISH ATTACK IN 1797.

BY CAPTAIN HENRY A. REED, UNITED STATES ARTILLERY CORPS,
SAN JUAN, P. RICO.

Read before Lyceum for 56th and 59th Co.'s, Coast Arty., February 25, 1901.

The first white settlers of Porto Rico, the Spaniards, who, soon after Columbus' discovery of the country in November 1493, began their exploration of the island and the exploitation of its mineral resources, were not long at peace with all of the native population ; and, as it usually occurs in like cases where the island is one of several not widely separated, the inhabitants of all having a common antipathy to the interference of strangers in their customs and laws and to the appropriation of their wealth, the settlers found themselves exposed to attack from the neighboring islands as well as by the Porto Ricans ; and, as soon as practicable, began their preparations for defense.

Some detail of cognate matters is necessary to a better understanding of the subject.

The present city of San Juan was not the capital, or principal city, of the settlers at first. Columbus first saw Porto Rico* November 16th, 1493, on his trip from Santo Domingo ; disembarking in the cove of Mayaguez on the southern shore December 19th, and departing for S. Domingo the 22d.[1] April 24th,† 1505, the king of Spain by royal order entered into a contract with D. Vincente Yañoz Pinzon, commander of the Niña in Columbus' 1493 voyage, to colonize Porto Rico, and appointed him mayor (corregidor) and warden (alcalde) of the fort he was to construct. Pinzon turned the undertaking over to Martin Garcia de Salazar, who, in conjunction with Pinzon had already acquired cattle interests in the island. This contract provided that Pinzon should construct the fort at his own expense, have the command of it during his lifetime, and the right of naming in his will his successor who also should have a life tenancy.[1]

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[1] History of P. Rico, by Fra Inigo Abbad y Lasierra.

* Which he named San Juan de Bautista. Still given, sentimentally, its Indian name "Borinquen."

† Navarrate gives March 24th.

These events show that Porto Rico was not forgotten by Spain between the dates of Columbus' discovery and the advent of Ponce de Leon.

Ponce de Leon visited Porto Rico from Santo Domingo in 1508 by permission of Governor Ovando, of the latter island, for the purpose of thoroughly exploring it, which he did, and with such satisfactory accounts of its fertility and mineral wealth that the admiral, Diego Colon, in the absence of Ovando in Spain, immediately sent 200 Spaniards to colonize it; but put them under Juan Ceron, whom he appointed lieutenant governor of Porto Rico instead of Ponce de Leon who reasonably expected the preference. The latter, however, by the efforts of his friends Ovando in Spain was soon, March 2d, 1510[2]—made governor of the island; and the same year had occasion to send Ceron to Spain a prisoner.[3]

When Ponce de Leon returned to Santo Domingo in 1509, the Spaniards of the northern coast were congregated at Caparra and its vicinity. The ruins of this first capital of the Spanish settlers are about three miles almost due south of the present city of San Juan. Caparra was frequently referred to in those days as "Puerto Rico."

The Spaniards were then at peace with the natives who had been divided up among them as laborers. The natives generally considered their masters as immortal until a chief, Broyoan, urged on by sceptics, drowned one in the river Guarabo (now Añasco). After watching the corpse three days, asking pardon of it meanwhile, the natives, tired of being hard worked and maltreated on the plantations, took heart and the trouble began.[4] On a certain Friday, in 1510, or early in 1511, a general uprising was arranged by Agueynaba and other principal chiefs, but was delayed by the prowess of Diego de Salazar, of Sotomayor,—the other principal town, on the southern coast,—who put to flight three hundred natives, in rescuing a son of Pedro Juarez, who had been kidnapped and put up as a prize for the winners in a game of ball, they having the privilege of putting him to death. Don Cristobal de Sotomayor, governor of the southern district, had news of this uprising, but discrediting it he and his people were surprised; and, in the massacre that followed, he was killed. A few Spaniards escaped and reached Toa-Baja, whence, joined by those there located, they fled to Caparra; all isolated Spaniards were killed, and the total deaths were but little less than half the Spanish population of the island.[1] A sally from Caparra resulted in the killing of about 200 natives. Then, in 1511, a general war was inaugurated. Ponce de Leon sent to Santo Domingo for assistance, which was not then forthcoming, and the natives invited the Caribes (natives of the adjacent islands) to join them against the Spaniards.[2] In the main battle which then took place, in the province of Añasco, one hundred Spaniards against eleven thousand natives, field fortifications were first employed in Porto Rico. The Spaniards were successful, Agueynaba was killed, and the Porto Ricans, of themselves, never thereafter menaced the Spaniards with an army of any considerable numbers.[3] In 1512, there were small uprisings; In 1515, an insurrection, soon put down; and for some years thereafter, the chief, Loquillo, taking shelter in the mountains of that name, rebelled against the authorities.[4]

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[1] Notes on same by Julian de Acosta y Calbo, page 22.

[2] Ibid, page 33.

[3] Herrera, volume VII, page 195.

[4] Herrera, Oviedo and Reynal.

In 1512, as a douceur to D. Diego Colon, Ponce de Leon was replaced in the governorship by Juan Ceron; but, soon after his trip to Florida, he was appointed an adelantado (provincial governor).

In April, 1515, it was proposed to remove the resident government from Caparra to its present location,—the island of San Juan.[5] It is stated that, during this year, the Prior Fathers Geronimo, (a name given to one of our present fortifications), who were sent from Spain as the ecclesiastical governors of the Indies, visited Caparra. In 1519, the change from Caparra to the island of San Juan was decided upon, and carried out in 1520, although opposed by Ponce de Leon, who was permitted to remain in his fine stone residence in Caparra.[6] It is believed that some of his children lived subsequently in Casa Blanca, one of the best located and most commodious houses in San Juan, recently occupied by engineer officers of the Spanish army, and now by United States army officers.

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[1] **Herrera and Oviedo.**

[2] **Herrera and Oviedo.**

[3] **Herrera and Oviedo.**

[4] **Notes.**

[5] **Notes.**

[6] **Notes.**

In 1521, Ponce de Leon disappeared from the scene, having died in Cuba soon after his return from his second trip to Florida, and his remains are said to rest in San Juan, under a tablet, in the cathedral of San José.[1]

In 1526, San Juan is described as a poverty stricken place, although the capital of a rich country.

The inquisition was represented in Porto Rico about this time, but did not long survive; and the present site of Fort San Cristobal is given as the place of its auto-de-fès.[2]

Ponce de Leon's residence in Caparra was the first fortification constructed in Porto Rico, and it served as a defense against the natives.

October, 1514, the king Ferdinand, addressing the officials in Seville, said: "Since in the cities of Porto Rico (Caparra) and San German," (six miles from Guanica), "two forts are constructing, where our chiefs and the citizens may be secure in case of rebellion, you will give arms and ammunition to Ponce de Leon, so that having them in his house in Porto Rico, with an artilleryman, all on our account, said house may serve as a fort." In fulfillment of this order, also of another of March 4th, 1515, there were sent to Ponce de Leon six espingardas (small pieces of ordnance), and other arms.[3]

In 1520, when the Spanish cabinet was notified of the move from Caparra to the Island, the advisability of constructing a fort thereon was suggested. The government provided for the construction of one house by contract. But little time elapsed before the necessity for defenses was determined. In 1527, England made a naval reconnoissance of the island; and August, 1528, a French vessel attacked and burned San German. Writing to Spain concerning these two events, Blas de Villasante said: "When we notified you in January last about the English vessel, we asked for guns and ammunition. Let them come without delay, or through fear our commerce will be lost." After the French attack, six lombards (small ordnance) were purchased and placed in the port.[4]

Therefore in 1528, there still existed no fort proper in Porto Rico.

In 1529, La Gama writers: The island is depopulating; it would be a good remedy to construct a fort," which representation was repeated by the city in 1530.

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[1] Notes.

[2] Notes, page 117.

[3] Notes, page 157.

[4] Notes, page 157.

Three years afterward this urgent necessity was provided for; —In March, 1533, the Audiencia of Española, (the government of the Spanish possessions, located in Santo Domingo), made the following disposition;—"That, it having been determined by the Council of the Indies that a fort shall be constructed for the city of Porto Rico, (San Juan), for which purpose there are deputed Garci Troche and Alonzo de Fuente, there may be taken from the chest of three keys, 400 pesos, and 100 from the city; and when this is spent, a like sum * * *."

In February following, Lando states: "If the fort might all be made of cut stone, the work would endure forever; to save expenses and avoid delay, I and the officers are disposed to build the sea walls of cut stone and the others of stucco." The government approved Lando's proposition, and the imposition of a tax to pay cost of construction.

In 1540, the work must have been nearly finished, because the city then requested the favor: "That the slaves, carts and oxen, used in the construction of the fort, may, when it is completed, be applied to buildings, bridges, etc., notwithstanding the ecclesiastics are asking for the money."[1]

This fort, according to the testimony of Father Torres Vargas, is the one that served and still serves as the residence of the governors-general of the island; preserving the name of "La Forteleza," notwithstanding its rebuilding and modification at different times.[2] Its name was changed by the present civil governor to "The Executive Mansion."

March and June, 1541, the treasurer, Castellanos, referring to La Forteleza, and to the fort to be constructed in San German, states: "As to the fort which is ordered constructed by me in San German, and of which I am to be the warden, although there is great lack of funds on account of the bills of exchange to the viceroy's wife and children, etc., as well as of the carts, negroes, etc., it will be constructed as best it may be. Arrange to send masons from Seville, as there is but one here; also tools, and twenty negroes. Meanwhile trenches can be dug, and a work for the artillery which should come immediately. Forts are all right in this island; but it is best to favor the people by loaning money or giving them free rentals for some years, to favor the sugar industry. If there were four or five armed vessels here, the enemy could not come without being captured. As the artillery has not come for the fort, how can the fort be defended?

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[1] Notes, page 158.

[2] Notes, page 158.

The port of San German consists of a bay and a strand ; the vessels lie about a half a league from the town, and artillery of good range is best ;—culverins of 60 quintals, half culverins, sacres (small ordnance), versos* of metal with two cannoneers for each, etc. I have begun the fort of San German, for which purpose I bought some negroes, hired others, and I pay them wages at the rate of two and one half pesos a month."

The work in San German soon ceased, the officials stating that the occupants of the town wished to emmigrate.

The Forteleza in San Juan having been completed, there was urgency for artillery and ammunition, and the demands therefor were repeated to Spain and Santo Domingo.[1]

In 1555, the licentiate, Caraza, states that there were 8 bronze pieces for the Fortelez and Morro and 2 balustrades ; which implies that work had already begun for a defense on the summit of Morro.

Oviedo had recommended the Morro site for the first fort, stating: "It should have been placed at the point of entrance of the port, whence the vessels at sea could be seen, and not as now where the view is limited to the inside of the port. Certain it is, that if they might have built it blindly, they could not have found a more unsuitable place. The remedy for this is to construct on the point I refer to, a tower, (Martello tower), something more than a watch tower, that may contain some artillery, so that no vessel can draw near." They were not long in following Oviedo's advice ; and 'upon that extremely important point was constructed, first, a battery, and subsequently, a magnificent castle, for such it was in those days, was gradually furnished with an armament.

Father Torres Vargas states that the plan of the castle was traced 1584 ; that during this year Don Juan de Tejeda, the governor of Cuba visited Porto Rico, accompanied by chief engineer Don Juan Heli, who then traced the plan of Fort El Morro as it now exists. The fort was then called "San Felipe del Morro" and the present Santa Elena Battery the "Morillo of Sata Elena," or the "Morillo." In 1599, Governor Alonzo Mercado continued the undertaking by constructing a well, and a cavalier that goes by his name, and placed on the latter the coat of arms that Phillip II gave him for it,—a miniature redoubt from which projects an arm bearing a sword. Evidently at this epoch El Morro was not far advanced, because it was passed by and the city and the fleet within the channel assaulted at close range by Sir Francis Drake in 1595, and again by Count George Cumberland in 1597. In 1606, additions were made and the present main parapet, the most elevated part, must have been well on the road to completion, as it bears the tablet commemorative of its construction as of that date. Two years later, in 1608, Governor Don Gabriel de Rojas completed the Austrian cavalier, the best one of the fort, the casemates and another well; and, on this date, the title of "Alcalde" (Warden), hitherto borne by the commander of the Forteleza, passed to El Morro.[1]

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* Demi-culverins.

[1] Notes, page 158.

Governor Rojas also built the Cañuelo, (then called San Jaun de la Cruz),—the isolated fort between El Morro and Palo Seco,—and a redoubt called "El Boqueron" which was located on or near the present site of San Geronimo, at the boqueron (mouth) of the eastern entrance to the bay.

The armament of the fortifications and prominent points at this date was as follows;

In El Morro, 27 good bronze guns and	5	small ones,
" Santa Elena,	4	small bronze guns,
" La Forteleza and vicinity,	8	" " "
" El Tejar, (in La Marina),	9	" " "
" Palo Seco,	2	" " "
" El Boqueron,	4	" " "
At the bridge, (San Antonio),	6	" " "
" " head of two streets, "Cabron" and "Morillo," (between Fortaleza and El Morro);	5	" " "
		in all, 70 pieces.

The misfortunes of the city attending the assault of the Prince of Orange's fleet under General Boudoyno Enrico in 1625 revealed the necessity for more fortifications; so, in 1630, the governor, Henrique Henriquez de Sotomayor, began the construction of the wall of circumvallation, which was finished in 1641 by Don Inigo de la Mota Sarmiento, leaving three gates or sally ports and several emplacements for guns; one of these gates with the part of the adjacent wall, extending from San Cristobal to the rear of the theatre, was removed in 1807. Fort San Geronimo and the Antonio redoubt were begun in 1636, presumably by D. Inigo de la Mota.[2]

Finally, in the 18th century, was constructed the castle of San Cristobal with its strong advanced works. It was begun in 1740 and finished in 1771.[3]

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[1] Notes, page 159; Archives of Porto Rico; Cayetano Coll y Toste.

[2] Cayetano Coll y Toste.

[3] Cayetano Coll y Toste.

In the 19th century, some fortifications were added, notably El Escambron and San Ramon,—the former, in its present state, within the last decade.

October 18th, 1898, all of these fortifications passed from under the jurisdiction of Spain to that of the United States of America; Battery B, Fifth U. S. Artillery, commanded by Captain T. B. Adams, occupying El Morro and the works to the south; and Battery G, same regiment, commanded by Captain H. A. Reed, occupying San Cristobal and the works to the east, Major S. A. Day, same regiment, commanding the artillery battalion.

In the three main assaults, or sieges, referred to, of Drake and Cumberland in 1595 and 1597, respectively, and of the Netherlands in 1625, the fortifications were few and far between; but, in 1797, when the English under Sir Ralph Abercrombie and Admiral Henry Harvey attacked the city, all of the present forts, save Escambron and San Ramon were in existence, and a brief synopsis of this event will exemplify their employment a century ago.

The affair lasted from April 17th until May 2d. The English fleet consisted of 60 vessels and about 14000 men,—abont 6000 to 7000 of the army, and an equal number of the navy.[1]

The war vessels were a ship of the line, a three-decker, of 120 guns; two frigates, one of 40 and the other of 36 guns; two brigantines of 16 and 18 guns respectively; four corvettes, 16 guns; and 18 schooner privateers, each of from 6 to 12 guns; a large store ship and transports.[2]

The force assembled to withstand this attack will be observed as the narrative progresses.

The fleet appeared off the port about 6 a. m. the 17th; and although the flag was not shown, it was soon discovered by the maneuvers that an attack was intended. The Capt. General, Don Ramon de Castro, with his staff, the chiefs of the different departments,—after satisfying himself by observation from El Morro that he had a fight on hand—immediately put his preconceived plan into operation. The general alarm was sounded, and the troops sent to their stations; arms were distributed to enlisted civilians; Don Francisco de Paula Castro was given charge of the 4 lighters, 2 pontoons and 12 gun launches; Lieutenant Colonel Linares with 4 field guns and a flying corps, taken proportionally from the other troops, was sent to prevent a disembarkation, to use his judgment as to the manner thereof. All the commandants and chiefs of the line received their special orders ; a company of cavalry was ordered in from the suburbs, also others who could be useful in the city's defense ; the necessary service was furnished to the artillery park and the fortifications ; all the posts of the district were reinforced and supplied with arms, munitions and tools. Provisions were ordered brought in from the neighboring country. Powder from outside store houses was rushed into the place and stored in the magazines and in boats provided for that purpose in the bay.[1]

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[1] Don Pedro Tomas de Cordova.

[2] Notes, page 190.

By 10 a. m. the fleet was discovered to be English, and its movements indicated a contemplated landing on the Congrejos beaches (now Santurce).

Men were sent to costruct a line of defense in the vicinity of Escambron ; and an engineer with the necessary means to construct a battery to prevent the passage of the Martin Peña bridge. Two pontoons, each with two 16 pounders, were located at the harbor entrance ; two lighters similarly armed to Martin Peña, and two to defend the San Antonio bridge. The gun launches were used to reinforce these pontoons and lighters and in readiness for service where most needed. The ecclesiastics were assigned to the hospitals and like service.

The enemy sent two frigates to blockade the port.

The cavalry company arrived at night, and 40 men were detached therefrom to reinforce the flying corps.

At break of day the 18th, the fleet began a lively cannonading to protect the landing of its boats.

The flying corps had reached its destination ; and, divided into three detachments, had entrenched and was ready to prevent the landing. Toro, one of the detachment commanders, killed all but one man of one of the launches filled with troops sent in his direction. The number of launches was then greatly increased, about 3000 men making the attempt, and the three detachments were obliged to retire ;—Toro and Linares to Martin Peña, and Viscarrondos to San Antonio bridge, according to their previous instructions.[2] Linares and Toros soon found that the enemy were making for San Antonio bridge and hastened to join Viscarrondo, who, finding it inconvenient to withdraw his two guns, disabled and buried them, when all three retired, leaving advanced parties protected by the guns of San Geronimo and at San Antonio. The enemy observing these forts, stopped their forward movement, and retired also leaving advanced posts.[3]

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[1] Notes, page 189.

[2] Notes, page 190.

[3] Notes, page 191.

Viscarrando was ordered out to annoy them, having with him some French volunteers, 50 men of the permanent regiment, some militia and 30 cavalry. They moved by three separate routes toward Congrejos, with orders to rally, if necessary, on a point left in charge of a captain of cavalry with 40 men. The party moving toward the plaza of San Mateo skirmished with the enemy, who immediately advanced from the plaza, in number apparently 3000. Viscarrando was ordered to retire, and the Captain General observing the situation from San Geronimo, stopped the enemy's advance by the fort artillery; and the San Antonio bridge was ordered cut through.

To prevent a conflagration from the enemy's fire, all straw roofs were ordered removed from city dwellings.

A flag of truce was received requesting the surrender of the city, granting many privileges. It was refused in the following terms, worthy of note showing the loyalty of the residents to their king. "Excelentisimos Señore:—I received the note of this date from your exellencies suggesting to me the surrender of the fortified town of Puerto Rico, that I have the honor of governing; and which I will defend, as due my catholic king, even to shedding the last drop of blood. This condition prevents me from accepting the generous offers that your excellences are disposed to make, especially to me, to my garrison and the inhabitants, who like their chief, are disposed to sell their lives dearly. I hope that, in its defense, I will attain the glory that I achieved from the British nation at the village post of Pensacola in 1781. May our Lord preserve your excellencies many years, as I desire. Puerto Rico, the 18th of April, 1797.—Ramon de Castro. To their excellencies, Señores Don Ralph Abercromby and Don Henry Harvey."

On this day, three gun launches, after some skirmishing, reinforced the troops at Martin Peña bridge, and a continuous fire was kept up till after dark, to prevent the advance of the enemy in that direction.[1]

The night of the 19th, a fast mail schooner was prepared for despatching to Cuba to request assistance. The enemy reconnoitered Cabra island and the Cañuelo, and were fired upon from El Morro, the Wall and San Cristobal; but without effect, owing to the great range. A flying corps, under Lieutenant Colonel Linares, and a pontoon detached from the harbor entrance, were sent to Palo Seco to observe the enemy's movements. San Geronimo was reinforced with a mortar and more ammunition.

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[1] Notes, page 191.

400 men arrived at Rio Piedras, of whom 200 were brought to the city, the rest remaining to observe the enemy's rear guard. Toa Alta sent in 51 men. Several suspects in the city were arrested and confined.

On the 20th, a brigantine and two gun launches joined the blockading squadron ; San Geronimo, San Antonio and the lighters kept up their fire, and shell were effectively used against a battery posted on the Condado hill.[1]

110 volunteers were sent to assist in observing the English rear guard. An instruction camp was formed for the newly armed country people. The commandant of the Marina numbered all the small boats in the bay, and assigned them as transports between the city and the different camps. Food supplies were gathered and stored, and well protected.

A flag of truce explained to the English admiral the flying of the French flag over one of the works defended by French volunteers. A frigate joined the blockading squadron, which approached nearer, making toward Point Salinas ; but neither the guns of Morro or the Cañuelo could reach it. Four gun launches, under Lieutenant Hurtado, were sent to Palo Seco.

During the night, the blockading brigantine anchored near the north extremity of Cabras island ; but, at dawn, the Cañuelo and San Fernando batteries, with their 36-pounders, drove it away minus an anchor.

From deserters it was ascertained that the enemy had disembarked between 6000 and 7000 men, some heavy artillery, howitzers and mortars ; and that 400 or 500 French prisoners were in their ranks.

There were 25 prisoners and deserters from the enemy. 325 men joined from Guainabo and Caguas.[2]

On the 21st, a ship of the line and a brigantine of the English fleet put to sea.

Linares had a skirmish with the enemy's rear guard near Martin Peña, killing several English soldiers, and capturing 32 prisoners, including a subaltern ; while the Spaniards' loss was 5 killed and 20 wounded.

San Geronimo was reinforded with two 24-pounders, and two mortars of 8" and 12" respectively, for the special purpose of reducing two English batteries posted, one at 225 yards and the other at 360 yards east and south of San Antonio bridge to attack that point.[3]

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[1] Notes, page 195.

[2] Notes, page 194.

[3] Notes, page 195.

The engineer, Mascaró, reinforced the latter with two 8-pounders, to prevent a crossing at that point. The battlements of the bridge were also cut away.

An intermittent fire was kept up by the forts. At night the enemy's works were lighted up by a party of Spaniards setting fire to pitched canvas placed beyond the bridge; a lively skirmish ensued, in which the artillery from forts and lighters joined; but, as in most affairs of this kind, little damage was done.

From deserters, it was learned that the enemy's main camp was at San Mateo, to which point he was transporting his artillery and stores, preparatory to a general advance.[1]

Spaniards' casualties, as above, 5 killed and 20 wounded.

530 men joined from Toa Alta, Vega-Baja and Manati.

The 22nd several vessels joined the blockading squadron, apparently for the same duty.

The enemy were dragging guns toward their works; some veteran regiments, recognized by their standards, and cavalry came into view; and, as the news was received from spies that the Admiral desired to attack the city right away, every preparation was made to defend the bridge crossing, now a ford, to the last extremity; a trench for 400 men was dug on the farther side; chevaux de frise were placed in the stream, and boards with projecting spikes on its borders, which were mined; the bridge opening was palisaded, and San Geronimo gorge protected by a parapet, and one 8-pounder and two 12-pounders placed there, and mines of loaded shells in front of it. Field guns were placed in the San Cristobal trenches, and 1500 infantry and a cavalry company were held in readiness in the vicinity, and to protect a retreat from the advance posts if necessary. Hand grenades were distributed. The advanced posts as well as the lighters and launches were reinforced. Cavalry patrols were extended from the bridge to San Geronimo, to prevent a landing at night on that beach under cover of an attack on the bridge.

22 deserters and prisoners received in the city.

323 men joined from Junco, Arecibo and Cayey.[2]

On the 23rd, the blockading squadron moved a little farther seaward for safety against a N. or N. E. wind, the weather up to this time, however, having been pleasant. Some of the vessels were observed moving towards Point Salinas with launches in tow, evidently through information from their spies, to intercept the mail schooner prepared for the trip to Havana. As this route of communication was closed, despatches were sent across the island, to be forwarded from there.

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[1] Notes, page 195.

[2] Notes, page 196.

The flying corps in the suburbs was ordered to harass the enemy's rear guard ; A 12-inch mortar was placed at the bridge ; and an intermittent fire was kept up day and night to annoy the enemy's working parties.

22 prisoners and deserters were brought in.

On the 24th, General Castro knowing and extremely regretting the impossibility of a general offensive movement of his troops, on account of the little experience of most of them determined on a sally ; for which Lieutenant Diaz, with 50 of the prison guard and 20 disciplined militia, was selected.[1]

At early dawn, the party having embarked in small boats escorted by launches, entered the San Antonio cove ; and landing as near as possible to the enemy's trenches, made their way cautiously towards them. Meanwhile the forts and floating batteries kept up a lively cannonading of the enemy's works to distract their attention, and ceasing to use projectiles as soon as the party was endangered by them. Diaz attacked the working parties at short range, drove them to the number of 300 out of the trenches, and captured a captain and 13 men. The fleeing laborers alarmed the camp ; and Diaz, not finding time or means to disable the seven pieces he found mounted, took to the small boats, and, under cover of heavy fire of the forts, returned with his prisoners and the loss of but 1 man killed and 3 wounded. The General, who had watched the affair from San Geronimo, was greatly pleased with the exploit, and distributed 500 pesos among the party as a reward.

The bridge opening was further strengthened to resist a brusque attack ; and the Juan Diaz bridge in the interior was ordered cut to prevent the enemy's progress in that direction.

A lively fire was opened on the bridge ; and the projectiles gathered indicated the use of 8, 12, 24 and 36-pounders, and 9 inch mortars. This was correspondingly replied to by the Spanish artillery with considerable damage to the enemy. As a result of the affair San Antonio required a good deal of repair, which was effected that night.

A proclamation pardoning deserters, who had left previous to the beginning of the siege and without aggravating circumstances, was made, so they might assist in the defense.

Spaniards' casualties, 2 killed and 15 wounded.

147 men joined from Utuado.

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[1] Notes, page 197.

On the 25th, the enemy's heavy guns wrought havoc with the bridge battery, requiring large working parties for continuous repair. The narrow site made it impossible to protect men or stores, especially from the Condado guns; so, on that side, a parapet was constructed, and the guns placed in it soon dismounted the Condado gun that was doing the most damage.

Covered ways were dug leading to the bridge battery, to protect men and working parties.

San Geronimo was well battered, and the commandant, Colonel Teodomiro, had the flat roofs of both main structure and guard house covered with sand, to prevent shell from entering and exploding in the rooms, which had already resulted in some casualties. A shell from this fort blew up one of the enemy's ammunition deposits, setting fire to material; and the gunner received 10 pesos from the Captain General for his fine shot.

The enemy were observed making toward the Miraflores powder magazine, to which they had free access, the contents having been brought to the city when the fleet appeared, and the place left undefended. It was first thought best to destroy it; but, as it was not bomb proof, this could readily be done subsequently if necessary by the artillery.[1]

A frigate approached San Geronimo, but a few trial shots showed that it could not effectively take part in the bombardment. Hot shot were in readiness in both Morro and Cristobal for ventures of this kind.

Spaniards' casualties;—4 killed, 9 wounded; also wounded, the engineer, Mascarò and Captain Quiñones of the artillery.

7 prisoners and deserters from the enemy.

204 men joined from Coamo and Aguadilla.

On the 26th, a frigate was observed anchored near Point Salinas with a launch detached; the gun launches gave chase to the latter, but were driven off by grape fire from the frigate.

Another gunner was rewarded with 10 pesos for dismounting a gun which was doing great injury to the bridge fort.

An attempt was made, with 60 negroes transported in small boats protected by gun launches, to dislodge the enemy from Miraflores; but, after some good work, they were finally driven to their boats by 300 infantry, 30 mounted troops and 2 field guns,—the gun launches covering their retreat.

To protect the advanced trenches from an enfilading fire from Miraflores, traverses were constructed. A mortar was located on the San Cristobal cavalier, and one on its place of arms; and all the 24-pounders, from this castle to the Pedro Martin battery, were made ready. Two lighters were so placed, one in the bay, and the other in the Martin Peña cove, as to enfilade the Miraflores battery.

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[1] Notes, page 199.

Firing was kept up throughout the day, the advanced forts requiring a continuos supply of sand bags to repair damages.

A canoe was stationed near the bridge to gather in any deserters that might present themselves.

Spaniards' casualties; 4 killed and 20 wounded.

15 deserters and prisoners from the enemy.

A company of cavalry joined from Añasco.[1]

The 27th, a foraging party consisting of a captain, a lieutenant and 16 men from the enemy's rear guard, was intercepted and captured.

The firing had continued all night with much damage to the bridge.

Mortar fire on Miraflores was tested; but the effective range was only about half the distanace; while a trial of the 24-pounders showed them of damaging effect.

All the gun launches were ordered to San Antonio bridge for readiness in case of a sudden attack.

Another futile attempt was made by three vessels in the way of a naval bombardment of San Geronimo.

Spaniards' casualties ;—3 killed and 9 wounded.

19 prisoners and deserters from the enemy.

100 men joined from Ponce.

The 28th, between 3 and 4 o'clock a. m., the enemy opened on the plaza from Miraflores with 36-pounders, 2 mortars and a howitzer,—using shell and fire balls. Some of the projectiles reached the city, one setting on fire a subsistence store house; but the greater number either exploded en route, or fell short. This was continued till 8.30 or 9 a. m., when a lively fire from the city, and especially from a 9-inch mortar on a pontoon in the bay, silenced it.

They kept up their fire all day and night with good effect, even to preventing repair of damages.

Blindages were placed to protect the artillery practice school, used as a powder storage magazine, and two guns were placed on the lower level of San Geronimo, directed eastward, to pevent the passage of the Boqueron. Fascines were made and stored in readiness.

Spaniards, casualties ;—18 wounded.

252 men joined from Toa Alta.

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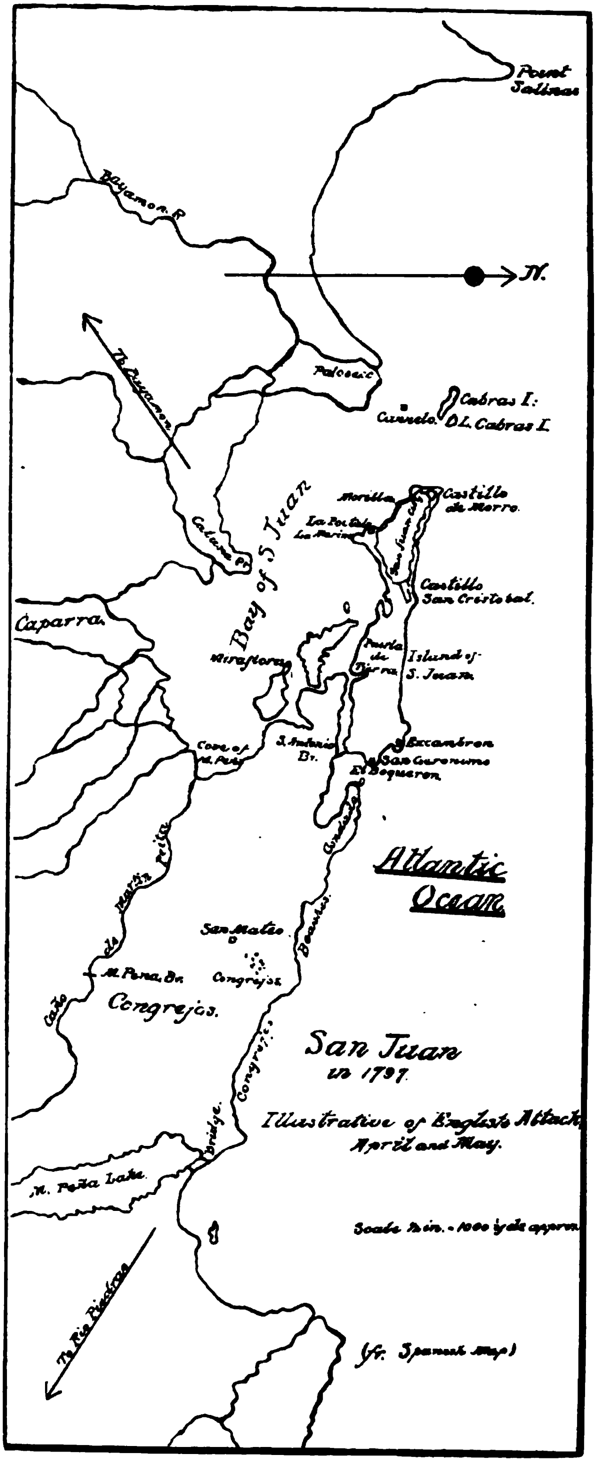
[1] Notes, page 200.



The night of the 29th, 100 laborers in small boats made the passage of the Boqueron more difficult by unloading stone blocks in the channel.

During the day, a dispatch boat and a sloop joined the fleet; Miraflores was bombarded, and was enfiladed with good effect from the lighter in the bay. Two more men were awarded 4 pesos by the Captain General for extinguishing the fuse of an enemy's shell. Three frigates and three vessels of lesser size approached Point Salinas, apparently with the intention of disembarking troops; and dispositions were made to prevent it.

A general attack by the enemy was looked for, and all of the advanced posts were reinforced.[1]

The Spanish General, finding it impracticable on account of his undisciplined and inexperienced troops,—only 200 were veterans,—to attempt an advance in force, then planned a flank and rear attack; and gave orders for its execution on the following morning, beginning at day break.

Lieutenant Canales with two guns was to take post near Martin Peña spring and open on General Abercrombie's headquarters and the main camp, retiring if necessary toward the bridge, which was reinforced. Lieutenant Luis de Lara, in charge of troops at Rio Piedras, with his men including two companies of cavalry, to move towards Martin Peña bridge and improve his opportunities. Sergeant Cleimpaux, with a flying corps of veterans joined to a party of militia, to so post his troops in rear of the enemy's works as to cut the enemy off in case of retreat. A general bombardment of the forts was to be the signal for the attack.

Casualties, to the Spaniards, this day, 4 killed and 5 wounded.
4 prisoners and deserters from the enemy.
208 men joined from Peñuelas, Aguada and Tuna.[2]

On the morning of the 30th it was observed that much damage had been done to the enemy's batteries at Miraflores, by the incessant all night firing; and that few men had been left there.

The forts opened up with a lively cannonading. Lieutenant Lara, of Rio Piedras, had not a clear conception of the General's plan of attack for this morning. Instead of co-operating with the others, he advanced with 800 men, infantry, two companies of cavalry and some artillery, straight to the Martin Peña bridge, where he was warmly received by the enemy entrenched and with artillery; and after deploying and the exchange of several volleys, he was compelled to retire. The combined attack was frustrated.

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[1] Notes, page 204.
[2] Notes, page 205.

Spaniards' casualties, for the day, 3 killed and 36 wounded.

36 prisoners and deserters from the enemy.

102 men joined from Ponce.

May 1st. The enemy's artillery fire had ceased the midnight preceding; but since the early evening of the day before, a continuous musketry fire had been kept up along the marshes, as well as along the higher ground extending northward through the enemy's camp; which was attributed to a desire to prevent any attack by the Spaniards.

Early in the morning, the English camp was unusually silent, and hurried embarkation was believed to be taking place. The General, immediately, with three companies of cavalry, set out to attack the enemy's rear guard, and harrass them generally while embarking. They had, however, gotten on board by 7 a.m.; and at 10 a. m. a fine breeze carried them seaward.

Many guns, spiked; an artillery train, provisions, etc., were found, and a guard placed over them to prevent pillage. 45 stragglers were gathered in.

On the 2nd of May, the blockading squadron set sail, the San Antonio bridge was repaired, the spoils of war brought into the city, and the English dead buried to prevent infection. 28 more English stragglers were arrested.

On the 3rd of May, the Te Deum and high mass were sung and celebrated; and a sermon was preached in the cathedral by the senior bishop of the diocese.

Under date of April 13th, 1799, the King of Spain rewarded the city for its patriotism on this occasion by bestowing upon it the title of "very loyal and very noble," gave it an additional scroll for its coat of arms to the like effect, made it a free port for at least twenty years, and granted it other general and special favors.[1]

Fort El Morro, San Juan, Porto Rico,
February 10th, 1901.

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[1] Notes, page 206.

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NOTES ON RAPID-FIRE FIELD ARTILLERY.

TRANSLATED FROM THE FRENCH BY CAPT. W. W. GIBSON,
ORDNANCE DEPARTMENT, U. S. ARMY.

NOTES ON THE CONSTRUCTION OF ORDNANCE.

Washington, April 1, 1901.

II.-NEW SWISS FIELD ARTILLERY MATERIAL. MODEL 1901.

[Extract from the "Revue Militaire Suisse."]

In a communication to the Federal Assembly dated the 8th of March, the Federal Council proposed the adoption of a new artillery material for the mounted batteries of field artillery. This field artillery material will be called "model 1901." The message begins as follows:

The important question of arming field artillery with rapid-fire guns has for a number of years past been an object of profound study in most armies. Some of the states in our immediate neighborhood have already decided upon the new armament for the artillery. Others will follow in a short space of time. The German artillery was provided in the years 1896 to 1898 with new rapid-fire guns and completed its armament in 1898 by the introduction of a light field howitzer. France has proceeded in the last few years to a complete transformation of its mounted batteries. In Italy rapid-fire field guns will be provided, first for the light batteries and doubtless later for the heavy batteries. In Austria experiments being made with a view to the transformation of the artillery material will doubtless be finished this year. In other states trials have been in progress for several years and a solution will be found in the near future.

The transformation has for its object to provide the artillery with pieces suitable for accelerated fire, which allow the commanding officer to order rapid fire in certain battle situations. The modficiations made in artillery materal during the long period of peace through which we have been passing have increased its weight to such a point that it no longer fulfills the conditons of lightness that is required of field artillery material. The reduction in weight of the pieces and of the caissons would by itself render a transformation necessary.

The message successively reviews the competitive trials made in 1892 by Switzerland for the construction of new field and mountain artillery, as well as the trials which took place from

1892 to 1896. It gives the names of the superior officers appointed by the Federal Council as members of the commission on the new armament of the artillery. It details the credits voted by the Chambers for the trials of the new material. These credits amount at this time to the sum of 780,000 francs, of which at the end of the year 1900, 639,500 francs had been expended.

In granting these credits the Federal Assembly has shown the importance that it attaches to the study of the new armament, which has prompted the commission to follow this investigation in a very thorough manner. We are able today to bring to your knowledge the fact that the commission has arrived at the end of its labors so far as concerns the mounted field batteries and that it is at the present time following with great energy its experiments relating to field howitzers. As for the armament of mountain batteries, the commission can not propose any new piece which offers any advantages over the present design without introducing complications in organization and without prejudicing its mobility.

The commission has had occasion during the last four years to examine all pieces offering any interest for us, not only on the proving grounds of constructors, but on our Swiss firing grounds. The decisions of the commission are based upon the most recent trials. The commission, as well as several of its members, have been enabled, moreover, on repeated occasions to obtain information on the experiments being followed in other armies.

It is not possible to give in our message all the details relating to the labors of the commission or to the motives which have led them to make the most important decisions. Some of them, moreover, can not be published at the present time, for various reasons. We will give, however, in its general outlines a résumé of the report of the commission dated January 14, 1901. The reader is referred for the details to the report itself and to the appendices which accompany it.

REPORT OF THE COMMISSION.

STUDIES AND EXPERIMENTS IN 1897.

After its organization in May, 1897, the commission established in the first place a programme of the general conditions which the new field artillery material should satisfy. It was possible to follow this programme without sensible modifications until the end of the work. Its requirements have been met at all points in the material that we now propose to you. They have even been exceeded, so far as relates to rapidity of fire. Pieces satisfying the programme, which have been presented by Germany, Belgium, France, and England—and a number of pieces having recoil upon the carriage—were tried in the same year, 1897. Three of them had hydraulic brakes, one did not. The trials relating to the construction of shrapnel permitted some fixed principles to be established. The commission had occasion, moreover, to examine various mountain pieces without any of them, however, having been found meriting special trials.

STUDIES AND TRIALS IN 1898.

In May and June, 1898, trials were made with three chosen models. The fourth competitor withdrew of his own accord. In its place our present field artillery material was entered for comparison. The result of these trials is as set forth in our message of the 13th of June, 1898; in consequence of which you have granted us a credit of 300,000 francs for the purchase of a battery of six Krupp pieces with six caissons, constructed in the federal shops and with the necessary ammunition. Moreover, the commission made a number of modifications in the material presented and studied the modification of the present material.

The report of the commission for the year 1898 concluded as follows:

"The trials of the year 1898 have demonstrated that there are pieces which, with a weight of 200 to 300 kilograms less than the present, show ballistic properties superior and a projectile effect nearly equivalent to the present, while at the same time having a rapidity of fire twice as great as our present pieces."

STUDIES AND TRIALS IN 1899.

The principal work of the commission in 1899 was as follows:

1. Trial of Krupp battery of 7.5 centimeter guns.
2. Trial of field guns of 8.4 centimeter modified.
3. Experiments with field howitzers.

1. TRIAL OF THE KRUPP BATTERY OF 7.5 CENTIMETERS.—Trials of the battery of 7.5 centimeters took place, as far as possible comparatively, with a battery of 8.4 centimeters, and in two firing schools and in the post-graduate school for officers the same personnel served the two batteries, while in two courses of firing one of the batteries of a group was equipped with new material. The first system of assignment of the personnel was shown to be very defective, since it was impossible to obtain a good service of the piece and suitable management of the firing. It was also

found that the course was of too short duration to obtain a satisfactory formation for the personnel and an exact method for handling the battery in all respects. The elements which allow us to determine the effects of fire of a single piece are based upon experiments made on the proving grounds. If the results obtained by the experimental batteries have not been up to the standard the piece has promised it must be attributed not to the construction of the piece but to the data or to a method of conducting the firing not yet suitable for the new piece. The commission resumed its conclusions in the following way :

"It has not been possible to decide whether the increase in the effect of a single shot in the trial pieces would of itself be a sufficient motive for the transformation of artillery material. On the other hand a very important increase in the rapidity of fire was unanimously established as well as an increase in mobility and stability of material. The objections to the increased weights of our pieces, and especially of our caissons, do not appear in maneuvers where the artillery carry only drill cartridges. The comparative trials made this year with batteries equipped as for war also did not bring to light all these difficulties, the trials having taken place in extremely favorable weather and under special conditions for maneuvering."

"The members of the commission have unanimously declared, however, that an increase in mobility and stability was a decisive reason for transforming the artillery material on the condition, be it understood, that there should result from it, no reduction in the effects of fire."

It was proposed in consequence to arrange a series of special experiments for 1900 and to continue the investigation up to that time to ascertain if any perfected material existed.

2. Trial of Modified 8.4-centimeter Pieces.—Experiments were made in two courses repeated, of a battery of 8.4 centimeters modified (with folding spade). Generally speaking, the material modified by the federal workshops pleased the commission. Nevertheless, it is stated that the immobility of the piece during firing is principally due to the great weight of the gun and carriage. The modification caused a new increase of weight and a reduction of 3½ per cent in the vertical field of fire. With this modification of the material came corresponding improvements which were still more urgent, viz :

(1) Introduction of shrapnel fuses of longer time train.
(2) Adoption of a clinometer sight.
(3) Application of traveling brakes to all carriages.

(4) Provision of two extra caissons per battery in order to restore as far as possible the former supply of ammunition.

It is unfortunately not possible to simply add a spade to the carriage. These modifications necessitate a displacement of the axles (in order to diminish the weight on the trail) and a change in the footboards. The cost of these changes is quite considerble. Moreover they ought to be gradually made if it is not desired to put a large number of batteries out of the service at the same time. It is especially important that in any case a transformation of this kind may not relegate to an undetermined epoch the urgent question of light material, which, while being equal to the former material as far as the effect of single shot is concerned, may be capable at certain moments of more rapid fire and of firing at ranges superior to 3,500 to 4,000 meters, while it is reached by the enemy's fire. Moreover the numerous modifications which have already been made in our material and the great length of time it has been in service, render its defects every day more glaring.

After having weighed all the consequences and without any reserve whatever, the commission concluded to definitely condemn the transformation of the present material.

3. EXPERIMENTS WITH FIELD HOWITZERS.—The experiments with field howitzers not being finished, it is not possible to publish anything at the present time.

STUDIES AND EXPERIMENTS IN 1900.

At the beginning of the year a delegation from the commission attended the trials at Meppen of various Krupp pieces having recoil on the carriage. Proof was then given that the Krupp factory had for a long time been studying pieces of that character and had introduced many improvements in them. In the second week in February the following pieces having recoil on the carriage were tried at Thoune. First, a rapid-fire gun by Schneider & Co., of Creusot; second, a rapid-fire gun of the Ehrhardt system.

After the introduction of these two guns the commission decided to give up the trials of the Krupp pieces having reeoil on the carriage and to confine themselves to their decision of 1897 to reject any pieces having long recoil.

After these trials they made some experiments with a rapid-fire gun of 7.5 centimeters of the Nordenfelt system, made by the Cockerill Company at Seraing. The carriage of this piece did not have any hydraulic brake. The recoil is limited by spring shoes, which, at the moment of firing, are applied against the wheels. The majority of the commission decided that it would be advantageous to make a more extended trial with an entire battery. In our message of the 13th March, 1900, we proposed to you the purchase of a battery of four pieces of the Nordenfeldt-Cockerill system and a special course of experiments with it, comparatively with a Krupp battery of four pieces. You adopted our propositions of the 27th to the 30th of March, 1900.

For this special course of experiments the Krupp Company furnished on its part new carriages, offering over the old piece certain improvements especially designed to facilitate the service of the piece, so that the judgment which had been passed in 1899 on the service of the Krupp piece was no longer well founded. In the course of the summer the members of the commission had occasion to be present upon foreign proving grounds at trials with some of the most remarkable types of field guns.

The special trials took place from the 20th of September to lhe 20th of October, at first at Thoune, then in the environs of Zurich under the direction of the chief instructor of artillery. On the 17th of October, on the invitation of the military department, five members of the military commission of the council of States and four members of the commission or the National Council were present who had recorded themselves in favor of a credit asked to continue the trials. The minutes of the commission appointed to select a new gun contains the special report upon the result of this trial.

The commission called upon to decide between the two pieces, Krupp and Cockerill, gave the unanimous preference to the Krupp piece.

At the same time, before making the choice definite, the experimental station at Thoune was ordered to make a new comparison between the single fire of a rapid-fire 7.5-centimeter gun and of the 8.4-centimeter. These trials showed in this last investigation that the effect of the 7.5-centimeter is equal to that of the 8.4-centimeter, and that even superiority for the former may be looked for by improving the shrapnel. Finally, befor a decision was reached, an excellent opportunity was offered two members of the commission to be present on a foreign proving ground at some very complete comparitive trials between pieces having elastic spades and pieces having recoil on the carriage. The commission sought from the start to make this country independent of foreign countries in the construction of limbers and caissons as well as of the arrangements for ammunition. The director of the Federal shops of construction proposed an ingenious and extremely simple system for the packing of ammunition as well as a clever disposition for the ammunition chests for limbers and caissons. In the course of the trials, shrapnel furnished principally by the Federal shops was fired. The trials of shrapnels and their fuses have not yet been finished, but will be at an early date.

PROPOSALS OF THE COMMISSION.

At the end of the year 1900 the commission unanimously decided to propose the following:

The Swiss field artillery should be armed with guns and carriages with a spring trail spade designed by Fried. Krupp, model 1900, with wheels, limbers, and caissons constructed by the Federal shops at Thoune.

The commission adds:

"This decision has been taken with the conviction that, first, the great weight of the present material makes a new armament of the artillery not only necessary but urgent; second, the new armament that it proposes is very suitable to our circumstances. Its judicious use in important moments will make its fire superior to the present system and equal to that of foreign armies. In comparision with the present material, the proposed material presents the following advantages:

(*a*) *Mobility and stability.*

"1. The 7.5-centimeter piece with 40 rounds in the limber weighs from 220 to 280 kilograms less than the 8.4-centimeter gun with 35 rounds. The caisson of the 7.5-centimeter with 96 rounds weighs 600 kilograms less than the 8.4-centimeter with 105 rounds.

"2. The center of gravity both of the piece and caisson is considerably lower than in the present material. The carriages are therefor more difficult to overturn.

(*b*) *Fire; one cannoneer less per piece.*

"1. With the same initial velocity the trajectory is flatter at mean and great ranges.

"2. The shrapnel range is 5,600 meters instead of from 3,600 to 4,000.

"3. The rate of fire is 9 to 10 shots a minute instead of 3."

The message which we reproduce furnishes some comparative data on the two systems of material as well as a brief description of the Krupp material. We do not give it here. It will be found in more detail in the last part of this article. It also indicates the proposals of the commission relative to the purchase of material and ammunition. These last propositions are as follows.

1. The same number of pieces for the batteries as at the present time, as well as the number necessary for the schools and for reserve.

2. Two and one-half caissons per piece, one and one-half for the battery, and one for the park. This last also ought to be provided with some gun carriages in reserve.

3. The same supply of ammunition per piece as at the present time. At the same time its distribution will be greater in amount to the batteries and to the corps park and less to the depot park.

4. The adoption of a battery wagon.

"*We adopt,*" said the Federal Council, "*the propositions of the commission to introduce a new material for the mounted batteries of field artillery, and we agree with them as to the number of pieces, caissons, reserve carriages, and amount of ammunation to be supplied.*"

Under the subject of pieces having a long recoil on the carriage the message contains a long discussion which, as is known, has given rise to more or less animated dispute in some military and political journals of German Switzerland. It is interesting to reproduce it. It throws light on the motives which led the commission to omit in the last trials pieces of this type and to oppose the adoption of this system for Switzerland.

In proposing to you a piece with an elastic trail spade, we are not unaware that France has introduced pieces with very rapid fire and that a series of articles from various journals strongly recommend the adoption of pieces of this kind. They especially boast of the advantages of the Ehrhardt system. It is beyond doubt that together with pieces having an elastic spade, guns with long recoil deserve serious attention. The principle of the piece is as follows: The carriage remains fixed during firing. The gun alone slides in its cradle or moves with it a small carriage until its recoil is entirely absorbed by a hydraulic brake. The return of the piece into battery is accomplished by the extension of an elastic body in conjunction with the brake, a body which may be air, rubber, or metallic springs. The principal advantage of these guns it is said is in the fact that the gunner and the man loading can both remain seated on the carriage during firing. The mechanism for pointing being fixed upon the most stable part of the piece, the gunner can keep his eye on the sighting apparatus and rectify the pointing immediately. Thus, 15 rounds a minute has been attained. Such are the characteristics of these pieces as the commission recognized them. On the other hand, there is much boast of the immobility of the carriage in all positions; complete independence as regards the nature of the soil under the piece; less fatigue to the personnel; resistance and simplicity of material. These advantages the commission disputes, or at least considers them not yet demonstrated. The commission on the contrary, affirms that the manner in which the piece will function depends in the same degree on the nature of the soil as in carriages with elastic spades and that the duties of the cannoneers impose great demands on them. It absolutely denies that this material has a resistance and simplicity sufficient for a long employment in times of peace. The principal objection to even the best constructed systems of this type arises from the fact that putting the brake out of action causes that of the whole piece, while with the elastic spade, even if all the parts are broken, the piece will nevertheless be in condition for firing. It will simply act as our present material does without any rope brakes. The commission considers a rapidity of nine to ten shots a minute as more than sufficient, and believes that a greater rapidity could not be utilized because it is difficult to bring a greater number of shrapnel to the piece and to graduate them. Otherwise it would be necessary to make certain special dispositions which for actual service would be decidedly objectionable. It is easily lost sight of in comparing rapid-fire of artillery with that of small arms that as regards artillery each projectile demands a separate manipulation. Furthermore, the projectiles have to be handled one by one. We have already shown that the commission had the opportunity of examining all the various pieces with recoil on the carriage under the most varied circumstances. It also made firings with the Ehrhardt piece at Thoune and before coming to any definite decision, minutely weighed all the advantages in favor of pieces with long recoil. It arrived at the absolute conviction that there is no reason whatever for reversing its decision of February, 1900, to reject pieces having long recoil. The Ehrhardt piece can be compared to other similar pieces. It does not possess any marked advantages giving it an incontested superiority over pieces of long recoil made by other factories. The commission further states as follows:

"Examination of the various publications which have appeared in favor of pieces with long recoil on the carriage have led the commission to be convinced that its studies of the new piece and the data that it has gathered on the constructions in progress in other contries, allow it to examine thoroughly the advantages claimed for this type of piece and to pass judgment upon their value. The commission tried not only one piece but several. It made various experiments and its representativos have assisted at numerous trials in foreign countries.

"The material on which the commission based its judgment on this system was much more elaborate and complex than that upon which the authors based their opinions. The commission regrets seeing in publications favorable to long recoil, or at least in those which seek to depreciate the value of pieces having elastic spades, statements and conclusions not conforming to the facts, and having a tendency to lead persons less well informed into error. The reports that have been circulated regarding a new transformation of the German artillery in favor of pieces with long recoil have been denied before the Reichstag by the minister of war himself. Particularly interesting is the declaration of a partisan of pieces with a long recoil, Lieutenant Colonel Stang, of Norway, who wrote: 'Where the gun recoils on the carriage, a complete immobility of the carriage during firing has been obtained to the detriment, it is true, of a little simplicity and strength that some consider as indispensable in a system of artillery suitable for war.'"

The commission, through its studies, has arrived at the conclusion that it is just this lack of simplicity and strength that is not compensated for by any tactical advantages of a piece having recoil on the carriage, and that, on the other hand, this fault can in certain cases entirely compromise the usefullness of the piece. All the originality of the Ehrhardt piece consists in the construction of the carriage trail, which can be lengthened for firing and shortened during the march. This telescopic carriage is nothing new. French constructors brought some before the commission. The choice of a piece, however, should not be founded on this operation as long as its durability is doubtful. The arrangement for recoil upon the carriage necessitates a material increase in weight. This excess of weight ought to be elimated for a carriage wich is already overworked by ordinary marching. The reduction of weight below a certain limit may be the cause of grave dangers. They are frequently noted only later. As to the method for the fabrication of hollow bodies by the Ehrhardt Company, its advantages have not been demonstrated, especially for the construction of guns where guarantees for uniformity of metal are of prime importance. We have, moreover, at our disposal information regarding pieces with long recoil upon the carriage which it is not possible to publish here.

The judgment of the commission in regard to the material to be adopted does not rest simply on the result of proving-ground trials. It is founded on very clear general impressions which it has derived from actual handling of the material and its operation, and according to which in a well-conducted firing, the new material is very superior to the old and equal to that of other states.

The commission does not consider as absolutely inexact certain considerations relative to the effect of single fire on the organization and conduct of fire of batteries. It is nevertheless conceded that their thorough examination would require considerable time. It can only be settled in the course of a Campaign. No one knows what the future will bring forth. In questions of armament it is impossible to obtain an absolute solution. Those who will advise delay are right also in stating that war does not break out suddenly or that one need not fear being surprised by it during a period of reconstruction, which will perhaps take four years, if we wish to reconstruct the material in Switzerland. Let war happen as it may, one may judge of the moral and material influence of an inferior armament and may weigh its consequences in a fight where at certain moments a more rapid fire than with our present pieces is absolutely indispensable. The hopes that may be founded on a more perfect material in the future will not excuse, however, a complete and very long course of experiments with a single model and with an entire battery. A delay to-day would render the rational construction of the new armament very difficult and would hinder in the highest degree the formation of troops for the service of the new material. In the infantry, after his prelimenary training, the foot soldier can handle his musket. He can even form a certain judgment of its value. Rifle clubs also largely contribute to a settlement of the kind of new armament for the infantry. The foot soldier by himself forms opinions as to the characteristics of foreign arms and knows how to answer the exaggerated praises that are heard regarding them. The artillery can not do this. It is only formed in service. It is not only necessary to instruct the cannoneer in the service of the gun, but to prepare the officers for conducting firing with the new material. A proper instruction of the personnel with the new material requires a great deal of time, and, generally speaking, a transformation of the armament requires long and steady work on the part of the artillery. We find ourselves for the first time in the presence of a complete transformation of field artillery. It is not only a question of the piece, but the limbers and caissons and battery wagons, by reason of numerous modifications, have ceased to be of any service and their conditions as to weight no longer allow us to consider of their further use.

The Federal Council states:

"*We have followed the deductions of the commission. Its reports, its notes, as well as the various appendices which accompany it, have given us the conviction that the commission has followed its labors conscientiously and with perfect knowledge of the case, imbued with the responsibility which it had assumed and which it will continue to bear in the choice of the new material. In consequence we completely agree with its conclusions.*"

The message then goes on to specify the cost of the new armament. We sum it up briefly.

The expense, estimated at 17,600,000 francs, including ammunition, will to the amount of 600,000 francs be met by the sale of the old armament. For the balance, the Federal Council will negotiate a loan payable in ten or fifteen years. Four per cent interest and a period of fifteen years will make the annual payment 1,530,000 francs. If the loan has to be reimbursed in ten years the annual payment will rise to 2,096,000 francs.

Here, to finish, is the text to the decree which the Federal Council submits to the Federal Assembly, concerning the adoption of a new material for the field batteries.

1. The field artillery will be provided with new pieces, new caissons, and wagons, and with the necessary ammunition of the model "artillery field material, 1901," proposed by the commission on the new armament of the artillery.

2. The Federal Council is charged with taking the necessary measures for purchasing this material and for the fabrication of the ammunition. It is authorized to cover the expense thereof and to contract a loan to the amount of 17,000,000 francs and fix the conditions of this loan. The present decree will take effect immediately.

DESCRIPTION OF THE MATERIAL.

GUN.—The caliber of the gun is 7.5 centimeters. Its length is 30 calibers. It has 28 rifling grooves; of increasing twist and right-handed. The gun is of nickel steel and is composed of a tube which is reinforced at the rear end by a jacket. At the rear end the jacket is prolonged beyond the tube and forms a breech. All the left part of the breech is cut away to facilitate loading. The rear face of the breech carries on the right side a seat for the sight. Upon the right trunnion is the front sight holder into which the point ring sight is screwed. The chase ends with a slight muzzle swell. The sight is a clinometer sight of the Corrodi system. The sight groove is slightly inclined in order to correct the natural drift of the piece.

Breech Mechanism.—The breech mechanism consists of flat wedge of the Leitwell system. It opens to the right, which facilitates loading by the cannoneer on the left. Obturation is assured by the metallic cartrige case. The lanyard is hooked before the first round, and for all the firing, in the eye of the trigger at the front of the wedge. The trigger is a repeater; that is to say, in can be armed again in case of missfire without having to open the breech. The firing-pin spring is armed only at the instant of fire. The wedge is provided with an extractor which automatically ejects the case when the breech is open. The breech is opened and closed with a single movement. It carries a safety arrangement operated by hand which prevents a piece which is ready for firing from being fired and also the opening of the breech. Thus the piece can be maneuvered without danger while it is loaded.

Carriage.—The carriage is a rigid carriage with a spring trail spade. The flasks made of steel with angle irons are connected at the middle of their length by a transom to which is attached the rod of the column of Belleville springs and to the trail by a large curved plate forming a sort of shoe and provided at the rear with a lashing ring. The gun rests on a carriage by means of a small carriage pivoting around a vertical trunnion and capable of a lateral displacement of 3° on each side of the axis to correct pointing in direction. This movement is controlled by a handweel placed on the left of the carriage. The handweel on the right serves for pointing in elevation. The carriage has a footboard as in the present material and two firm supports for the cannoneers standing on the footboard. The wheels are provided with a traveling brake maneuvered by a screw and handwheel on the left of the piece controlled by the cannoneer mounted on the footboard. This brake can also be used for a firing brake if for any reason whatever the trail spade does not work. The folding-spring trail spade rotates around an axis carried by two supports fixed on the flasks. In marching on very bad ground the spade is folded up under the flasks. In firing the whole piece recoils upon the spade which relieves itself by compressing the column of springs. Their extension causes a return of the piece to battery. The piece is served by a chief of piece and five cannoneers. No. 1 on the right hand operates the breech mechanism, points, and fires; No. 2 assists him. No. 3 on the left introduces the cartridge. The two other cannoneers graduate the shrapnel and supply the piece with ammunition. If necessary the piece can be manned by three cannoneers.

AMMUNITION SUPPLY.—The ammunition is composed of a shrapnel with metallic cartridge case so as to form one complete cartridge. The piece likewise fires explosive shell but the commission proposes, however, that this sort of ammunition shall not be introduced. The shrapnel is made of steel with a rear chamber. The brass cartridge case with the primer at the base contains a charge of about ½ kilogram smokeless powder. The cartridge case can be used ten to twelve times. The fuse is a double-action fuse which will probably be made of aluminum with one step, and graduations corresponding to that of the sight. Its effective range is 5,600 meters.

THE LIMBER.—The limber of the piece and of the caisson are identical. The wheels are of the same dimension as those of the piece. The spokes and felly of the wheel are of wood; the nave is of iron. The chest opens to the rear. The lid folds down in such a way as to form a table. The chest contains 40 rounds packed in fours in a rattan basket in two layers of two. The cartridges are packed in jute cases. The chest carries on its rear end a crate for carrying the baggage of the personnel. Three cannoneers sit upon the chest. The footboard is provided with a foot rest. The chests of the limber and of the caisson are made of steel.

CAISSON.—The caisson is composed of a single chest opening to the front. It contains 56 rounds in two rows of seven baskets (plate 4). On each of the chests is an arrangement to receive the baggage of the cannoneers. Three men ride on the caisson. It is provided with a brake. The battery is provided with a new model battery wagon.

NUMERICAL DATA.

Caliber	centimeters	7.5
Length in calibers		30
Weight of gun with breech mechanism	kilograms	350
Weight of piece unlimbered	kilograms	912
Weight of piece and carriage without cannoneers	kilograms	1,692
Weight of the caisson loaded, without cannoneers	kilograms	1,684
Number of horses		6
Weight for each horse without cannoneers	kilograms	282
Number of rounds carried by limber		40
Number of rounds carried by caisson		56

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Gauge of track	millimeters	1,365
Diameter of wheels	millimeters	1,300
Height of axis of piece above the ground	millimeters	930
Field of fire, horizontal	degrees	6
Field of fire, vertical	degrees	+18
Field of fire, vertical	degrees	−12
Weight of cartridge, complete	kilograms	7.870
Weight of shrapnel	kilograms	6.35
Weight per square centimeter of section	kilogram	0.144
Weight of charge	kilogram	0.500
Number of balls, approximately		240
Weight of balls, hardened lead	grams	12.5
Rapidity of fire, per minute		9 to 10
Initial velocity, about	meters	500
Maximum range with time-fuse fire	meters	5,600

(To be continued.)

A DISCUSSION OF THE ERRORS OF CYLINDRO-OGIVAL PROJECTILES.

Translated from the French of General Douny in *Revue de l'Armée Belge* of January-February, 1900,

By J. M. Williams, 1st Lieut., Artillery Corps.

(Continued).

EQUATION OF THE CURVE OF PROBABLE VERTICAL ERRORS.

The problem is thus expressed:

A series of shots is fired from one and the same piece, mounted upon the same carriage, and aimed with a fixed angle. What will be the mean errors obtained in imaginary vertical targets, placed at various distances?

First let us suppose that there occur only variations of the first group, that is to say, variations that affect the angle of departure; and let us assume that at the first shot there occurs in that angle a variation $\Delta_1 \varphi$. The equation of the vertical projection of the trajectory,

$$y = x \tan \varphi - \frac{gx^2}{2v^2}\left(1 + \frac{2}{3}kx\right)\frac{1}{\cos^2 \varphi},$$

will become

$$y + \Delta_1 y = x \tan(\varphi + \Delta_1 \varphi) - \frac{gx^2}{2v^2}\left(1 + \frac{2}{3}kx\right)\frac{1}{\cos^2(\varphi + \Delta_1 \varphi)};$$

$$y + \Delta_1 y = x\frac{\tan \varphi + \tan \Delta_1 \varphi}{1 - \tan \varphi \tan \Delta_1 \varphi} - \frac{gx^2}{2v^2}\cdot\left(1 + \frac{2}{3}kx\right)\frac{1}{\cos^2(\varphi + \Delta_1 \varphi)}$$

and because of the relatively small value of φ, and of the very small value of $\Delta_1 \varphi$,

$$y + \Delta_1 y = x \tan \varphi + \tan \Delta_1 \varphi - \frac{gx^2}{2v^2}\left(1 + \frac{2}{3}kx\right)\frac{1}{\cos^2(\varphi + \Delta_1 \varphi)};$$

subtracting the first equation from this last one, we obtain

$$\Delta_1 y = x \tan \Delta_1 \varphi - \frac{gx^2}{2v^2}\left(1 + \frac{2}{3}kx\right)\left(\frac{1}{\cos^2(\varphi + \Delta_1 \varphi)} - \frac{1}{\cos^2 \varphi}\right).$$

Within the limits within which the variations $\Delta \varphi$ occur, the second term of the second number is negligible in comparison with the first term. Thus, at 2000 meters, $\varphi = 5° 44' 44''$ for the 8c gun; experience with practice at 2000 meters gives to $\Delta_1 \varphi$ a probable value of $1' 23''$, for the same piece; by making the calculations with these data, we find the first term to be equal to $0^m.80$, and the second to only $0^m.013$. In neglecting this second term, then, we make an error of a little more than one centimeter in *one of the components* of the total error, produced by all the causes of error combined. Now, according to the tables, the probable value of this last at the same distance, is $1^m.64$, and the above inaccuracy changes it only less than one centimeter, and that assuredly is negligible.

At distances less than 2000 meters the accuracy is greater still.

Then we can take simply

$$\Delta_1 y = x \tan \Delta_1 \varphi,$$

or better still, $\Delta_1 y = x \, \Delta_1 \varphi$; a result well known, moreover, and one upon which are founded the corrections made in practice.

A second shot with a variation $\Delta_2 \varphi$, will give in the same way $\Delta_2 y = x \, \Delta_2 \varphi$.

In a target at the distance x, the mean $\Delta \varphi$ of the errors $\Delta_1 y$, $\Delta_2 y$.... will be, then, for n shots

$$\Delta \varphi = \frac{\Delta_1 y + \Delta_2 y + \dots}{n} = x \left(\frac{\Delta_1 \varphi + \Delta_2 \varphi + \dots}{n} \right)$$

or

$$(\Delta y)_{\varphi} = x \, \Delta \varphi, \qquad (1)$$

$\Delta \varphi$ being the mean of the variations in the angle of elevation.

In the second instance let us suppose that only variations in initial velocity occur ; these act directly upon the initial velocity v, and indirectly upon the coefficient k, since the latter is gotten from the relation

$$k = A \frac{R^2}{m} V^2 = C \, V^2,$$

placing $C = A \dfrac{R^2}{m}$.

Substituting for k its value Cv^2, we shall find

$$y = x \tan \varphi - \frac{gx^2}{2 \cos^2 \varphi} \left(\frac{1}{v^2} + \frac{2}{3} Cx \right);$$

then for a variation $\Delta_1 v$

$$y + \Delta_1 y = x \tan \varphi - \frac{gx^2}{2 \cos^2 \varphi} \left(\frac{1}{(v + \Delta_1 v)^2} + \frac{2}{3} Cx \right);$$

whence :

$$\Delta_1 y = - \frac{gx^2}{2 \cos^2 \varphi} \left(\frac{(v - \Delta_1 v)^2}{(v^2 - \Delta_1 v^2)^2} - \frac{1}{v^2} \right).$$

Because of the small value of $\Delta_1 v$ in comparison with v

$$\Delta_1 y = - \frac{gx^2}{2 \cos^2 \varphi} \left(\frac{v^2 - 2 \, v \, \Delta_1 v}{v^4} - \frac{1}{v^2} \right);$$

$$\Delta_1 y = \frac{gx^2}{v^3 \cos^2 \varphi} \Delta_1 v.$$

So that the mean error Δy, due to variations in velocity will be

$$(\Delta y)_v = \frac{gx^2}{v^3\cos^2\varphi}\Delta v \tag{2}$$

Δv being the mean of the variations in the velocity.

Proceeding in the same way in the case of the causes of error of the 3rd group, we shall get:

1st. By representing by Δk the mean of the variations made in k by the change in the resistance of the air:

$$(\Delta y)_k = -\frac{gx^3}{3v^2\cos^2\varphi}\Delta k. \tag{3}$$

2nd. By representing by Δg the mean variation in the force which produces the vertical deflection

$$(\Delta y)_g = -\frac{x^2}{2v^2\cos^2\varphi}\left(1+\frac{2}{3}kx\right)\Delta g. \tag{4}$$

Let us see whether it would not be possible to combine this last error with the preceeding, as we are led to desire for several reasons:

1. The perturbing causes due to the resistance of the air would be combined.
2. The calculations would be simplified.
3. The deflection varies with the distance too nearly in the same way as does the error due to the coefficient of the resistance of the air, for the method of least squares to permit them to be separated with any certainty.

The expression $(\Delta y)_g$ may be written:

$$(\Delta y)_g = -\frac{gx^3}{3v^2\cos^2\varphi}\left(\frac{3}{2x}+k\right)\frac{\Delta g}{g}; \tag{a}$$

thus it has the same form as $(\Delta y)_k$, except that the constant Δk of the latter is supplanted by the variable

$$\frac{\Delta g}{g}\left(\frac{3}{2x}+k\right).$$

What would be the inaccuracy caused by substituting for this variable its mean value? If we calculate for the 8^c gun the value of the term in parenthesis, for the distances at which tne vertical deflection can be of importance, we find the following values:

$$\left.\begin{array}{ll}\text{for 2000 m.} & 0.00110\\ \text{for 2500 m.} & 0.00095\\ \text{for 3000 m.} & 0.00085\\ \text{for 3500 m.} & 0.00078\end{array}\right\}\text{mean} = 0.00092.$$

By adopting for 2000 m. the mean value 0.00092, instead of

0.0011, the difference—and here it is the maximum—would be 0.00018, or 16% of the true value 0.0011.

In admitting with General Mayewski that the total vertical deflection at 2650 m. is less than 1^{m}, its value at 2000 m. would be, at most, about 0^{m}.55. Without being able to estimate the mean variation that occurs in a vertical deflection of 0^{m}.55, we can assert that this variation will be proportionally less than that which occurs in the horizontal deflection, since the wind affects the latter much more. Now we shall, later on, establish that the mean variation in the horizontal deflection, for the 8^{c} gun, does not reach $\frac{2}{3}$ of this deflection. The variation in the vertibal deflection at 2000 m. would thus be much less than $\frac{2}{3}$ of 0^{m}.55, or 0^{m}.37.

If, instead of taking the value of the vertical deflection given by formula (4), we take that which equation (a) gives after the mean value between 2000 and 3500 m. has been substituted for the variable factor $\left(\frac{3}{2x}+k\right)$, the difference, as has been seen, will be 16% of the first value; that is to say, instead of estimating at 0^{m}.37 the maximum value of the mean variation in the vertical deflection for 2000 m., we shall take it as 0^{m}.37 x 0.84 = 0^{m}.31.

Now, according to what will be established further on, the mean vertical error, including all causes that affect the resistance of the air offered to the 8^{c} shell, is 1^{m}.919 for 2000 m. If we suppose that one of its components should be 0^{m}.37, and that we substitute 0^{m}.31 for it, the total mean error would be changed only about one centimeter.

We see, then, that we may without appreciable error include $(\Delta y)_g$ in $(\Delta y)_k$ by properly increasing the constant factor Δk. The term $(\Delta y)_k$ will then represent all the combined variations due to the resistance of the air.

Now let us suppose that variations occur in φ, v and k at the same time. These variations will produce errors sometimes positive, sometimes negative; so that, in each target, the center of impact will remain that of the mean trajectory. The total error Δy will be obtained from the relation

$$\overline{\Delta y}^2 = (\Delta y)^2_\varphi + (\Delta y)^2_v + (\Delta y)^2_k ;$$

that is to say

$$\Delta y = \sqrt{x^2\,\overline{\Delta y}^2 + \left(\frac{gx^2}{v^3\cos^2\varphi}\right)^2 \overline{\Delta v}^2 + \left(\frac{gx^2}{3\,v^2\cos^2\varphi}\right)^2 \overline{\Delta k}^2.} \qquad (5)$$

Finally, let us investigate the most general case: that in which we seek the mean errors of a system of artillery composed of a large number of pieces of the same model.

For each of the pieces the jump, the initial velocity, and consequently k itself, will be different: the mean trajectory of each of the pieces will then be different also; and if we try to cause the center of impact of the 2nd piece, for a distance x, to coincide with that of the first piece, it will be necessary to lay the second piece with a slightly different angle, φ'. Coincidence thus obtained, the mean error of the second piece will be calculated by means of equation (5), in which we shall substitute φ', v', and k' for φ, v, and k, and the mean variations $\Delta\varphi'$, $\Delta v'$, and $\Delta k'$ for $\Delta\varphi$, Δv, and Δk; but an examination of equation (5), or a simple numerical application, shows at once that, within the limits within which φ, v, and k vary for a system of artillery, it is absolutely useless to pay attention to the difference between φ and φ', v and v', k and k'; and that it is sufficient to consider the *variations* that occur in each of them. For example, the quantities

$$\frac{gx^2}{v'^3\cos^2\varphi'}\Delta v' \text{ and } \frac{gx^2}{v^3\cos^2\varphi}\Delta v'$$

differ by only tenths of a millimeter.

The mean error of the second piece will then be simply expressed by the relation

$$\Delta' y = \sqrt{x^2\,\overline{\Delta\varphi'}^2 + \left(\frac{gx^2}{v^3\cos^2\varphi}\right)^2\overline{\Delta v'}^2 + \left(\frac{gx^3}{3\,v^2\cos^2\varphi}\right)^2\overline{\Delta k'}^2}$$

in which φ, v, and k have their mean valve for all the pieces.

The mean error of the other pieces being obtained in the same way, the quadratic mean error ΔY* of the whole system of n pieces, is calculated by means of the equation

$$\overline{\Delta Y}^2 = \frac{\overline{\Delta y}^2 + \overline{\Delta' y}^2 + \overline{\Delta'' y}^2 + \dots}{n}$$

which, after substitution, becomes

$$\Delta Y = \sqrt{x^2\frac{\Sigma\overline{\Delta\varphi}^2}{n} + \left(\frac{gx^2}{v^3\cos^2\varphi}\right)^2\frac{\Sigma\overline{\Delta v}^2}{n} + \left(\frac{gx^3}{3\,v^2\cos\varphi}\right)^2\frac{\Sigma\overline{\Delta k}^2}{n}}$$

That is to say the quadratic mean error of the system is also gotten from equation (5), when $\Delta\varphi$, Δv, and Δk represent the quadratic means of the approximate mean errors of each of the pieces.

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* It must be observed that here it is a question of the mean error gotten by taking the mean of the mean errors of each piece with respect to its own center of impact.

The approximate mean error being equal to the quadratic mean error multiplied by the constant $\sqrt{\frac{2}{\pi}}$, we pass to the approximate means by multiplying the last equation above by $\sqrt{\frac{2}{\pi}}$; and the approximate mean error $\lrcorner y$ of a system of artillery will be

$$\lrcorner y = \sqrt{x^2 \overline{\lrcorner \varphi}^2 + \left(\frac{gx^2}{v^3 \cos^2 \varphi}\right)^2 \overline{\lrcorner v}^2 + \left(\frac{gx^3}{3\, v^2 \cos^2 \varphi}\right)^2 \overline{\lrcorner k}^2}$$

in which $\lrcorner \varphi$, $\lrcorner v$, and $\lrcorner k$ represent the approximate means of the mean errors pertaining to each of the pieces.

The curve of the mean errors will be gotten by calculating $\lrcorner y$ for each distance and using its value as ordinate, while taking the range as abscissa; its equation is then in the form:

$$y = \sqrt{(A\,x)^2 + \left(\frac{B\,x^2}{\cos^2 \varphi}\right)^2 + \left(\frac{C\,x^3}{\cos^2 \varphi}\right)^2}$$

A, B, and C being the constants for one and the same system.

This equation containing only three constants, in order to determine them it would suffice to know the empirical mean error obtained from firing a sufficiently large number of shots at three very different ranges.

If we had data of practice at more than three ranges, the method of least squares would enable us to use all, taking their relative weights into account, and the result obtained would have the greatest possible accuracy.

* * *

In practice, this method of proceedure will find application; but here we shall proceed in a different way, and shall try to determine directly the coefficients A, B, and C. The reasons for this direct search are of some interest.

In the first place, if it were necessary to prove the agreement between our theory and practice, it would not suffice to show that equation (5) corresponds to the curve of probable errors, for it is not established *a priori* that an empirical equation, even simpler, would not give equally satisfactory results. To be convincing the proof must be more complete.

Again, if we can obtain only a limited amount of firing data—as would be the case with a trial piece and expensive ammunition—the method of least squares would sometimes require, as we shall see, the results of a larger number of shots than are needed for the direct method of seeking the coefficients: this method has consequently a practical application.

Finally, this direct method will establish in a positive manner the part of the total error that is due to each of the groups of causes. We can thus draw useful conclusions.

Before pursuing our investigations, let us recall that, in order to obtain results that agree, for the different ranges, these results must be gotten :

Either from one and the same piece ;

From any number of pieces, each one of which has fired at each range the same number of shots as the others (this case is thus really included in the preceding);

Or, finally, from a very large numbes of pieces of the same system, employed at each range. We can then consider the errors obtained as belonging to a *mean piece*, and the agreement of the results, less surely than in the preceding cases, may still be satisfactory.

The practicable data that we have been able to collect, fulfill only this last condition, and pertain exclusively to the 8 and 9 centimeter guns. These pieces are, then, the only ones of which we may treat in the continuation of this discussion.

DIRECT METHOD OF SEEKING THE COEFFCIENTS OF THE CURVE OF MEAN ERRORS.

In the equation of the curve of mean orrors,

$$\sqrt{\left(A\,x\right)^2+\left(\frac{B\,x^2}{\cos^2\varphi}\right)^2+\left(\frac{C\,x^3}{\cos^2\varphi}\right)^2} \qquad (1)$$

the ordinate, that is to say the total error, is the square root of the sum of the squares of the ordinates of three lines :

The first, $y = A\,x = x \tan \Delta\varphi$, is a right line and gives the error due to the variations of the angle of fire.

The second, $y = \frac{B\,x^2}{\cos^2\varphi} = \frac{\Delta v}{v^3}\,\frac{gx^2}{\cos^2\varphi}$, in view of the small variation in $\frac{1}{\cos^2\varphi}$, approximates very closely to a parabola, and gives the error due to variations in initial velocity.

The third, $y = \frac{C\,x^3}{\cos^2\varphi} = \frac{gx^3\,\Delta k}{3\,v^2\cos^2\varphi}$, is almost a curve of the third degree, and gives the error due to variations in the resistance of the air.

1. *Determination of the Coefficient* $A = \tan \Delta\varphi$. It is easy to see that the two last curves are tangent to the axis of x at the origin, and we may conclude at once that the errors which they represent are inappreciable at short ranges.

In order to assure ourselves of this let us test it in the case of the 8° gun, assuming that its total error at 2000 meters, which experiences fixes at $1^{m}.96$, is entirely produced by the third term, Cx^3, alone.

Equation (1) then reduces to

$$y = \frac{Cx^3}{\cos^2 \varphi}$$

and we shall have in this case

$$1^{m}.96 = C \times \frac{2000^3}{\cos^2 \varphi},$$

whence $C = 0.000,000,000,25$, a value that is evidently too large since it comes from the supposition that variations in atmospheric resistance alone have produced the total error. With the aid of the coefficient thus obtained, calculating the error caused by the influence of the air at 200 m, we find $0^{m}.002$, a figure that is itself much too large; but which, under corollary I. of the law of composition of errors, is absolutely negligible in comparison with the total empirical error at the same distance, that error being $0^{m}.10$.

Analogous reasoning leads to identical conclusions in the case of the term B, and we shall hence conclude that *the total error at 200 meters, and even at 400 meters, is entirely caused by the variations in the angle of departure*, the other causes having so far an entirely negligible influence; a conclusion, moreover, that is conformable to experience, the empirical mean error at 400 meters for the 8° gun, being exactly double that obtained at 200* meters, which is possible only if equation (1) reduces, for 400 meters, to

$$\Delta y = \sqrt{(Ax)^2} = Ax,$$

the terms $\frac{Bx^2}{\cos^2 \varphi}$ and $\frac{Cx^3}{\cos^2 \varphi}$ being without effect.

For the 8° gun the 740 shots gotten at 200 meters in the ranging practice, enable us to determine very accurately coefficient A, from the relation

$$0^{m}.10 = A \times 200$$

whence $$A = 0.0005$$

The 824 shots fired at 400 meters give the same figure.

By following the same method in the case of the 9° gun we find, using the results of practice at 200 meters (260 shots), $A = 0.000615$; and using the results of practice at 200 meters (460 shots), $A = 0.000557$.

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* See the errors obtained at these distances from more than 1500 shots from the 8° gun.

Or a mean, taking into account the relative weights of the data, of $A = 0.00058$.

The right line, $y = Ax = x \tan \Delta\varphi$, giving errors due to variations in the angle of departure, is then determined. (Pl. I.)

Determination of the Coefficient $B = \frac{g \Delta v}{v^3}$. The mean variation Δv is the only factor of the coefficient B that remains to be known. We have deduced it from numerous series of initial velocities gotten by means of the Le Boulengé chronograph. The results should be grouped according to times of practice, in order to prevent the calculation of the accidental errors being ruined by the presence of constant errors. We know, indeed, that the initial velocity may vary with atmospheric conditions, and the influence of these is not to come into account, since we are seeking the variations of only one target practice.

For the 8^c gun the mean variation thus found is $1^m.19$. This is also, within one centimeter, the figure that can be deduced from the series of initial velocities collected in General Le Boulengé's "*Etudes de Balistique Expérimentale*"; and this, it may be said in passing, proves the perfect preservation of the powder and the excellence of the manufacture of the Wetteren establishment.

For the 9^c gun the mean variation is $1^m.12$.

But these numbers are affected by the mean accidental error of the chronograph; and, in order to rid them of it, it has been necessary to determine it by series of simultaneous observations of one and the same velocity by means of two chronographs. It will be found in a note at the end of this article, that the mean accidental error of these instruments is $0^m.37$ for velocities of about 380 meters, and $0^m.33$ for velocities of about 350 meters (when the targets are separated by 50 meters).

According to the law of the composition of errors, the *true* mean variation will then be for the 8^c gun

$$\Delta v = \sqrt{(1.19)^2 - (0.37)^2} = 1^m.13$$

The coefficient B is then completely determined, as well as the curve of errors due to the variations in initial velocity alone.

For the 9^c gun $\Delta v = 1^m.03$, and we deduce from it the corresponding curve.

(To be Continued.)

THE MODERN BATTLE AND THE EFFECT OF NEW WEAPONS.

A paper read before the Massachusetts Military Historical Society by W. R. Livermore, Major of Engineers,* April 8, 1889.

(Concluded.)

If we take the facts in the order in which they are presented on the ground, the principle of the offensive may be summarized as follows:

1. The troops should be kept in hand hy their chiefs that is to say they should be assembled in opportune time and at a favorable place and in a formation bearing the germ of the formation for combat.

2. The transition formation by which it passes from the formation of assembly to the formation for combat should be flexible and manageable, and lend itself readily to the march across the zone swept by the fire of artillery and infantry, with out maneuvre but by a simple extension of intervals and distances.

3. The formation for combat flows naturally from the preceding. The movement that results from it should be simple and not involve in principle any lateral movements, and should as it were mechanically direct an energetic and continued impulse towards the objective.

This formation for combat presents in the zone of march two successive and inverse phases; in the first everything is directed towards gaining ground, towards avoiding losses by a rapid and uninterrupted march by advantageous formations and by deriving the best advantage from the accidents of the ground. The several units succesively take theis distances and form the echelons of march.

In the second place on the contrary, the chain having commenced fire, the echelons sacrifice all considerations of vulnerability to the imperious necessity of placing themselves at such distances that they can usefully perform their part.

The distances are then reduced in suitable and well determined proportions which constitutes the echelons of combat. When this necessity is imposed, it should be conducted vigorously with muskets enough to obtain an appreciable result in a short time.

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* Now Lieutenant-Colonel, Military Attaché, U. S. Legation, Copenhagen. Denmark. The above paper, although written several years ago, is still very modern, and constitutes an interesting study in connection with the most recent wars.—Ed.

The attack should from the beginning, from the density of the chain, and the power of fire, aquire the moral and material superiority, which it is enabled to preserve by the entrance into the firing line of the supports and reserves.

5. The successive pushes of the supports and reserves carry the chain towards the position of the enemy, avoiding those prolonged stops in which the ammunation is consumed, and the enthusiasm (elan) of the troops is lost.

6. Finally in the dispositions adopted, a separate body should be formed for the shock independent of that of preparation. This body of troops, carefully concealed during the development of the action, appears on the chain on the moment of rapid fire and draws on the assault.

Last September the German Army was provided with a new system of tactics or "Exercise Regulations". Its object was to provide a larger scope for war training, at the same time maintaining the hereditary discipline and order.

The dedication says: The advantage gained by the simplification of many of the formations, should on no account be nullified either by verbal or written addition in the Regulations by anyone, for the purpose of obtaining increased outward uniformity, or for any other reason. The freedom intentionally allowed, in the training and its application, should not be limited by any restrictions affecting the principles of the Regulations. I am firmly resolved to punish with dismissal any contravention of this my will. * * * * WILLIAM. To the War Ministry.

The description of the battle deployments of the firing line is as follows:

214. The method of deployment of company colums on the battle front may be a very variable one. Generally the companies will at first be brought up in succession as they are required while the rest remain united under the lead of the battalion commander, but circumstances may require that the battalion shall give the first shape to the fighting line by introducing all the companies at once.

In advancing or retreating such a deployment is best effected in the direction of the march. At a halt—in deploying by the flank.

The order designates the Company on which the deployment is to be made by the shortest possible means, as well as the intervals and relative positions of the Companies. As a rule the first deployment will receive more depth than breadth, with a view to gradually reinforce the line and retain at least one company in reserve.

When the Battalions are separated to deploy for the fight their movements are regulated by fixing a common point of direction etc. etc.

It is expressly forbidden to establish a stereotyped form for deployment in specified cases. The skirmish fight belongs to the companies and is conducted according to the principles laid down in the school of the company.

82. The attack of a position completely occupied, and perhaps prepared for defense, should on the other hand, be planned by the Commander from the very commencement. The independant action of the individual should not be allowed to cause the deployment to be made at haphazard. The enemy has in this case, clearly surrendered the advantage of attack, the Commander consequently, gains the advantage of being in a position to choose the direction and manner of his attack. In such cases the deployment for the fight is made in accordance with the intention of the Commander, previous to commencing the action.

The difficulty of crossing ground commanded by the enemy's fire, may render it necessary to advance under cover of darkness. In such cases the troops would generally be advanced the day before, as far as possible without getting within range of the enemies fire, and the first line to push forward in the dark to such a position as would enable it to open fire at break of day.

A planned attack will only then have any chance of success, when it is able to secure a superiority of fire.

The superiority of artillery fire is the first thing to be aimed at. It prepares the ground over which the infantry attack has to advance.

Should the ground offer suitable rallying points in front of the enemy's position, these should be seized first. The larger deployments for the fight are effected in rear of such points. It is a rule for advanced troops to endeavor to get up as close to the position as the ground will allow in order to open fire.

Strong fighting lines will work gradually to the position, and endeavor to overpower the enemy with their fire. These will best be supplied by the troops whose duty it is to sustain the fight. When the fighting line has succeeded in arriving within a short distance of the enemy, the supports brought up as close as possible, should be ready for immediate action.

Until a superiority of fire has been gained, or the enemy appears to be seriously shaken, the assault can only be delivered at a heavy cost. The final stroke should therefore be deferred, until the necessary fire effect has been attained.

The fighting line will be the best judge of the result attained. It is the first to recognize when and and where the enemy's resistance is decreasing; it is able to avail itself more quickly of any advantage gained; the final assault will therefore frequently emanate from the fighting line. It then becomes the duty of the supports at once to follow the fighting line with a view to supporting it and to protect it from counter attack. Generally however the Commander of the fighting line should bear in mind that the order to assault should be given by him, and at the right time.

When the fighting line has arrived to within short range of the enemy, and, having been sufficiently reinforced, has paved the way for the assault by the highest attainable fire action, the bodies of troops echeloned in rear should be brought up to the foremost line without a halt, and together with it should deliver the final blow. The drums of all closed bodies, commence beating from the moment that the advance to the assault can no longer be concealed from view. Whether the closed bodies find themselves alongside or in rear of each other, what their formation is, and whether the Commander should still retain a reserve, depends entirely upon circumstances. In this most decisive moment of the attack there is only one watchword for a fighting line, and that is "Forward". Forward straight to the goal. The beating of drums, the continous sounding of the "Rapid advance" by all the buglers sets everybody, even the hindmost, in motion, and with cheers, the assaulting troops throw themselves upon the enemy.

Any further addition to the rules laid down above for regulating the procedure of the attack, is prohibited.

83. Procedure after a successful attack.—It is not sufficient to have captured the enemy's position.—Its retention should also be secured. This is effected by the pursuit of the retreating enemy, and by placing the points captured in a state of defense. Should villages, farmsteads, woods, etc., form part of the enemy's position, the attack on them should be pushed uninteruptedly through to the further boundary. The further pursuit does not, as a rule, consist of pushing on, but of firing on the enemy, during which time, the troops which have carried out the assault, occupy the position captured and reform. They will thus in a short space of time, be prepared for renewed operations.

84. The enveloping movement.—The superiority of fire essential to success, can be most easily secured by an enveloping

movement. This should be provided for beforehand in the original dispositions, either by advancing from different directions, or by causing the troops in rear of the firing line to join in the attack.

Attempts at executing enveloping movements with portions of the infantry in the foremost fighting line, already extended and probably even already engaged, where they are not specially favored by the ground, are not likely to succeed, and lead to a mischievous splitting-up of forces.

The French tactics of 1887 differ materially from those of 1884 in that the successive lines are crowded closer together and all their efforts are directed to reaching the hostile position as quickly as possible—whereas in their former system the assault was looked upon as a very hazardous operation to be undertaken and conducted with utmost caution.

Until quite recently the French drill book was far superior to the German—but all the French systems are too rigid, the tendency to formulate is too strong.

The French charge appears to be far more a matter of sentiment than calculation.

The form of assault is an excellent one, provided the enemy is not too strong in numbers or position, but in the hands of an inexperienced Commander it would quickly degenerate to rashness.

The German drill book at first sight is most unsatisfactory, it appears to be non-committal and indefinite, and the sense of each paragraph appears to be contradicted in the next. But on closer study this impression is removed and when it is considered in connection with their excellent system of field maneuvres it is entitled to great respect.

But before accepting all its provisions we should bear in mind that all the battles in the last wars assumed a stereotyped form and the Germans have been unwilling to consider the possibility of other situations.

Moreover it is impossible to say that some of their leaders do not entertain views that they have not publicly expressed.

The principle that a firing line must be at first very open and gradually reinforced and made denser is by no means of universal application.

The principle that a tactical body once thrown into the firing line on the offensive can never be relieved has been so long reiterated that it has become an axiom and while it serves to mark the great advance of recent methods over those of 25 years ago, it is in its broad sense directly at variance with the fundamental principles of tactical science. It appears that all European Tacticians consider only the passage of lines at close quarters and overlook the great advantages that may sometimes be derived from relieving the firing lines at distances that would indeed be very long for old fashioned fighting but very short compared with the range of modern weapons.

The stereotyped form of assault adopted by the French and until recently by the Germans is only possible when the enemy is either surprised or on the march and are unable to take advantage of natural or artificial shelter or when this position can be subjected to a long bombardment of artillery fire or enveloped by a long line of infantry that can concentrate its fire on a narrow front.

Occasions sometimes arise where it becomes necessary to carry a strong position by a direct frontal attack: one small fraction of the enemy's line may hold the key to the position ; if this position cannot be surrounded it may be worth while to sacrifice more men to carry it than all the hostile force that holds it.

With magazine guns a position of this character if not regularly fortified may be carried by bringing up successive lines, each gaining more or less ground to the front and after firing several hundred rounds per man retiring to a place of shelter in the rear.

The formation of groups on the firing line at first sight appears to be a step in the wrong direction—but a little calculation will show that skirmishers will suffer but little more at long range in groups of four men at distances of 10 yards apart than if the men were deployed over the intervening space, for if the fire were so accurate as to make the loss appreciably greater at the centre of these groups than half way between them it would be accurate enough to kill every man in either formation in less than two minutes—for in ordinary fire a man standing half way between the groups would receive half as many shots fired at each group as if he stood in the centre of the group.

With regard to the organization of the German company and the tactical use of the company we must not loose sight of the fact that the latter is the successor of the old battalion column of about 1000 men and that the same principle that required a reduction of its strength to 250 men will require a further reduction to 60 or 80 men in the modern battle; in the best organization, preserving the same multiple throughout, the section is composed of four sets of four men, the company of four sections, the battalion of four companies, etc.

Artillery.—The leading features of artillery tactics are as follows:

1st. It is brought into action as early as possible in the fight and maintained until the last.

During the action it is pushed well to the front if possible.

If however the ground permits, it takes up a position to fire over the heads of the infantry.

Whenever commanding positions and long ranges are available the artillery is massed as much as possible.

The old rule was to mass the fire but scatter the batteries both to avoid loss from hostile artillery and because it was thought that a large mass of artillery offered too strong inducements to unfriendly cavalry to charge and capture it.

Cavalry.—The Europeans have never learned to dismount their cavalry to fight on foot: in this they have not profited by the lessons of the American War.

But the Germans made excellent use of their cavalry in 1870 by covering their entire front with an impenetrable screen hundreds of miles in length and far ahead of their main body so that the French were always ignorant of their positions; whereas by continual hammering they discovered the lines of least resistance of the French and formed a fair opinion of their movements.

This work however would have been accomplished better if they had been taught to fight dismounted and reinforce their fire with that of mitrailleuses on the battle field. A force of cavalry so equipped could move with confidence and celerity; if they should encounter cavalry of the old type their skirmish lines could fall back and the support could so maneuvre as to draw the enemy into the fire of the mitrailleuses or if a small group attempted to capture these guns they would be met with the fire or sabres of the reserve.

A force of cavalry and mitrailleuses could operate with horse artillery of heavier caliber as follows: The heavy guns take up positions on commanding heights; the mitrailleusses are distributed along the line wherever a moderate field of fire can be formed and thus the dismounted cavalry are only required to fill up the chinks in woods, villages and rocks and then with their magazine guns and an unlimited supply of ammunition carried on pack animals they can perform the formation of infantry to advantage.

Our little Army has been so reduced, so impoverished, so overloaded with unmilitary labors on the stale pretext of economy that all attempts to practise this new science are attended with great obstacles.

Bull Run or the first assault on Plevna would afford but a feeble picture of the first battle between a well disciplined European Army and any force that we could raise to oppose it, if we should fall into the ruts that we made a quarter of a century ago.

It is quite true that the principles of tactics have not changed and never will change but the forms are so altered that they would certainly not be realized by those to whom the older style of fighting has become a second nature, and herein lies our great danger unless some serious and persistent effort is made throughout the country to rescue us from that state of fearfull helplessness. We must organize a large reserve and practice it long in maneuvres that will offer at least a fair picture of the positions of opposing armies under the conditions of modern warfare before we can hope to avoid the dangers of the most stupendous butchery.

We must immediately set to work to provide our army with suitable weapons and material of all kinds before we can hope to inflict any loss upon our adversaries.

We must organize an efficient general staff composed of officers who devote their lives to the building up of military science before we can hope to accomplish anything with our armies.

We must learn all we can from European nations about their methods and their state of preparation; and we must afford the needful facilities to all our soldiers and allow our citizens who are so disposed to learn the principles of the new science.

INFANTRY UNDER GERMAN ARTILLERY FIRE.

BATTLE FORMATIONS AND MARCH TO THE ENEMY'S LINE.

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(Concluded.)

INFANTRY UNDER ARTILLERY FIRE.

Infantry may find itself exposed to artillery fire in five situations: At long distances, either in route column or in close formation; at medium distances, where it has nothing much to fear but cannon fire, for instance during the march to battle; at short distances, where it is simultaneously struck by artillery and by infantry fire, and, finally, at all distances, when it remains motionless on the defensive.

Whatever may be the distance and the formation, infantry should seek to make itself as inconspicuous as possible by traversing ground covered with crops, grapes, vines, or brushwood, and by taking advantage of every obstacle.

If the ground, although uncovered, be undulating, the regulation of the fire may become very difficult when the target is situated in the rear or in front of a ravine. In the first case, the percussion shots which are short are not observed; in the second case, the long shots are not observed; and in both cases, the determination of the range by means of percussion fire becomes well-nigh impossible. The artillery must then find the range directly by fuze-fire which is very slow work. However unskillful the troops may be at maneuvering and however inattentive their commander, they will have gained a shelter by the time the range is found.

Great Distances.—These considerations make it so that at very great distances the infantry will only in exceptional cases have to suffer from the fire of the artillery, for example, when it is compelled to pass over a portion of route previously marked out by the hostile artillery. However short the visible section may be, the said hostile artillery with the elevation found in advance, will execute a rapid fire which will be truly crushing for the body of troops as soon as it arrives upon this section. If the route is perceived over a length of several hundred meters, the artillery will execute a progressive fire at intervals of 100 meters; as a single battery can fire fifty shots per minute and as the amount of probable deviation is just about six meters, it is apparent that about twenty-five projectiles could, in one minute, fall upon a road eight or twelve meters wide, and that they would produce genuine havoc, especially if the infantry is marching in columns of eight. As soon as the first shots are fired, the whole column marching along the exposed portion of the route must break away from it and by a flank movement rush into the neighboring fields. Let us hasten to say that this instance is exceptional, for, although the sight of the F. K. '96 is graduated up to 5,000 meters, the German regulations forbid, as being useless, fire at these enormous distances at which even when something is seen it can only be distinguished very poorly.

Medium Distances, from 3,000 to 1,300 Meters.—It would not be the same if the columns of infantry should deploy to take a position opposite the objective which they have to carry. It is not doubtful that, upon the enemy's observation of this movement deployment, his artillery would endeavor to oppose it by taking full advantage of its range, accuracy and great flatness of trajectory. As soon as 1300 meters is reached, and at times even before, the troops should quit their route formations and assume the order preparatory for battle in order to execute the march to battle.

Let us examine the case of a battalion assigned to the first line marching against a designated objective and let us not lose sight of the fact that this battalion is compelled to move in a zone which we may suppose to be flat and the width of which does not exceed 400 meters. Let us admit that this zone is shelled by two German batteries of six pieces with a battle front practically equal to the battle front of the battalion.

What are the least vulnerable formations that this body of troops can take in its march to battle?

We know that the effectiveness of artillery fire depends upon:

1st.—The rapidity of accuracy of ranging.

2nd.—The efficacy of the projectile.

3rd.—The number of shells fired, that is,—the rapidity of fire.

These conditions, especially the last two, depend upon the weapons employed. Now, we know that a battery of model '96 field guns when the fire is once adjusted, can deliver, within a rectangle 150 meters in width by 350 in length, 50 shrapnel each throwing 300 bullets.

As to regulating the fire, in what does this operation really consist? In placing the shots in the direction of the target. If the target be broad, as deployed lines appear, the regulation of the fire will be comparatively easy, since, wherever a projectile falls, in front or in rear of these lines, the relative position of the point of fall can be accurately judged. Moreover, not only will the regulation of the fire be easily accomplished, but the efficacy of the projectile will also be very great. Whether the shell bursts at 10 meters or at 150 meters in front of the target, the continuous line formed by the target will always intersect the sheafs of bullets and fragments.

The formation in line, in one rank or in two, is therefore to be absolutely prohibited for marching; in fact, it is not useful to infantry except when they have to use their rifles—therefore only momentarily and especially at short range. On the contrary, the chances of hitting are less if the infantry, advancing in line of thin columns, marching with different depths and separated from each other by wide intervals, presents a front to a certain extent indefinite. For a battery established perpendicular to the line of march upon a target thus constituted, the cloud of smoke produced by the bursting of the shell makes it difficult to determine the exact position of the target in regard to this noncontinuous objective.

Many of the shots fall to the right or the left of the columns and are wasted. The dense, thick and persistent smoke of the Prussian shrapnel masks a thin target and forms a sort of screen to assist its being hid from view. The objection may be made that if a shot strikes exactly upon a column the resulting losses may be very large, but even when the shrapnel bursts at the right height the bullets, many thrown to the right or left doing no damage, do not render much more than the first ranks hors-de-combat.

It must not be forgotten, in fact, that the bullets of shells, even at short ranges, can not penetrate more than one man. On the other hand a calculation of the distribution of the fragments permits the admission that out of 100 bullets of a sheaf of dispersion the mean trajectory of which is directed against the feet of the first rank of a series of screens intercepting the whole breadth of the sheaf, 50 fall in front of this first rank, 20 strike the first rank, and 22 only reach the other ranks. Finally, when the fire is distributed over the different zones of an extended formation of a deployed line, the shots directed upon a particular zone, on account of the opening of the cone of dispersion, make some hits upon neighboring zones. Upon thin columns with large spaces between them, the cones of dispersion directed upon a single one do not hit the neighboring ones.

It is necessary then to march in line of columns. It remains to determine the depth of these columns and the intervals to be maintained between them.

RELATIVE VALUE OF THE VARIOUS FORMATIONS.

In order to settle these two questions, let us realize as accucurately as possible the vulnerability of a body of infantry under an adjusted artillery fire.

For this putpose, in the battalion of which we are studying the march to battle, let us take one of the companies of the first line. Each one of the 200 men composing it presents, standing up, a surface one-half meter square. The company in a single rank, standing up, will present one hundred square meters,—the maximum of its vulnerable surface. If it is formed in two ranks, being quite well covered or in files, this surface reduces to fifty square meters.

In column at full distances the vulnerability will be the same as a line in two ranks. In fact, with the great number of bullets contained in each sheaf, and with the different angles at which these bullets strike the ground, the four sections, separated from each other by distances equal to their front (16 to 18 meters), can not afford mutual protection to each other, and they are struck just about as if they were in the same line. Arithmetic and geometry prove this.

If the sections shorten the distances and close up as in company column, they protect each other. The vulnerable surface becomes expressed by the surface of the first rank (12½ square meters) of the head section, increased by the visible portion (head and shoulders) of the other sections; that is, of the part of these sections which project perpendicularly upon the normal plane of the sheaf.

The more the sections are massed, the more will their liability to danger lessen, and it is probable that if we admit a mathematically uniform distribution of the bullets, the formation theoretically least vulnerable would be that consisting of a perfect full square. In this order all the company, arranged in 14 ranks and 14 files, would have a front of ten meters and would be ten meters deep.

However, such a mass, recalling the Macedonian phalanx or the sacred Theban battalion, could at a single shot be half destroyed by a shell bursting in its midst; at least it could have its morale completely lost. Moreover, it would not permit the men to make use of their weapons and it would render the march very laborious. It is therefore unacceptable from a tactical point of view. But, without increasing its theoretical vulnerability, this formation becomes practical if divided in portions of four or two men front. This remark leads us to study the formations by the flank of the sub-divisions which have the great advantage of being manageable, mobile and supple, and of adapting themselves to the march upon all kinds of terrain however varied.

The formation presenting itself first to the mind, is that by the flank in four ranks. This is customary in our infantry which has only two square meters front. The depth of this column, of more than 80 meters for a company of 200 men slow to deploy, only exceptionally permits complete concealment from the enemy's view by means of the accidents of terrain. The column's vulnerable surface, obtained by the projection upon the plane normal to the mean trajectory of the sheaf of the visible parts of all the files, is quite considerable, since it is superior to that of a section line. There is occasion to remark also that, if the companies of the first lines each take up this formation, the opposing batteries, in place of distributing their fire widely upon the entire zone of action, will concentrate their fire upon each company, and will rapidly succeed in successively destroying these different columns.

Under the same fire a company will be struck fifty per cent. less when in two columns than when in one, that is, in marching by platoons. It will be still less struck if, in place of marching by fours, the march is made by twos or even singly ; but we reject *a priori* this last method, which offers no consistency, lengthens the company considerably, and makes it long to advance in line. We will restrict ourselves to the march by twos ; if we continue the reasoning followed above, we shall be led to advocate the sectionizing of the company down to the squad.

It is thus that a Prussian officer, professor at the Engers War School, who has studied this question very closely, came to recommend the sub-division of the company into 24 groups of eight men each, marching by twos.

We de not share this opinion and we estimate that there is a limit to the subdivision into fractions upon a zone of limited width. This limit is reached when the interval between two adjoining subdivisions is less than the mean length of the sheaf which is 25 meters in the case which we are considering. In order that a company may be divided into half sections, that is to say, in order that it may be formed in eight small columns, it must have a minimum front of 200 meters. Now, in the defensive, and abiding by our maneuvering regulations, the front of a company drawn up side by side will only in exceptional cases exceed 150 meters. If, with such a front, the company is formed in half sections, two adjoining columns can be effectively struck by bullets from the same shrapnel.

It is expedient, moreover, to take into account the fact that upon the battlefield the artillery lines are very much extended and that certain batteries, thanks to the great range of modern guns, can fire upon troops marching toward this objective, despite their distance from the threatening objective.

The effectiveness of this oblique, and at times even flank fire, will depend upon the length of the columns, if they are considered individually, or upon their closeness, if they are taken in their entirety. From a side view they appear, in the first case, to constitute a deployed line, in the second, a column at full distances. These two formations, as we know, are the most susceptible to damage.

In the normal formation of battle it is, therefore, suitable to avoid fractional division not having an interval of 25 meters between them.

The tactical organization of the infantry section commanded by an educated and experienced commander, either an officer or an adjutant, and which, besides this commander has two noncommissioned officers, seems to us to be well adapted to the march by the flank. In this march, as we shall see farther on, it will be necessary to constantly train the men, while it will also be imperative to know how to make a judicious choice of the ground. These small sectional columns of 25 files of two men each are not sufficiently long to lessen the authority of the commander, and, in less than 15 seconds, all the soldiers therein can be in line to make full use of their weapons.

From 3,000 to 1,300 or 1,200 meters, our battalions will therefore advance in two lines from 300 to 500 meters apart, each line formed mainly by sections moving by the flank without lapping. But will these sections march in each line wfth the same depth, the guides regulating their march, as is indicated by the drill book, by the battalion flag charged with directing them? To this question we reply "NO" without hesitation.

The two companies should each march in its sector, and in each of them the different subdivisions will advance in irregular echelon. This march at different depths, which greatly facilitates the utilization of the forms of the terrain should be combined with a certain irregularity of gait, thus rendering it possible to alternate, in a very changeable manner, the times of march properly speaking with the times of halting. We consider this precaution necessary in order to diminish the fatigue of the troops as indispensible to their security. If the march is continuous and at a uniform rate, the enemy's artillery, with its methods employed in firing upon a moving target, could easily follow the assailing body and inflict upon it severe l .

During moments of halt the troops will take the lying-down position if it is not behind a masking shelter; standing or kneeling in a contrary case. Above all, one should not forget that, whatever be the formation, the lying-down is one-third as dangerous as the standing position.

THE ADVANTAGE OF OBSERVING THE ENEMY'S FIRE.

The knowledge of the system of artillery fire of the Germans makes it possible to partly escape the damages of its effective fire. Unless it be a fire directed on marked zones, the troops forming the target of fire are warned, by seeing where the shots fall,—the latter constantly getting nearer the troops until they are brought within the fork.

We know that in four or five shots fired within less than two minutes, the artillery succeeds in finding the fork of 200 meters. After this, at least in firing as far as 1,500 meters and more, effective time-fuse practice is taken up. Four cases may arise:

1st. All of the shots fired are short, a part of the sheaf of bullets, however, reaching the lines. Stop as long as possible behind cover, however insignificant, and remain there until the fire becomes over, then briskly take up the march in advance.

2nd. The shots fired are over. There is every advantage in advancing, but without modifying the speed of march, so that the enemy's battery may continue to incorrectly calculate the troops' position; then stop a short time and again take up the march if the shots continue over.

3rd. The shots are alternately over and short. The fire is to be regulated; if the troops are very near the over shots, they must lie down and allow the effective fire to pass over them; if near the short shots, take the running step, get past the point where the shots fall and lie down; thanks to the smoke of the short shots, the advance movement may pass unperceived and the enemy's effective fire will be wholly lost.

4th. The observation of the points of fall is incomplete, although the troops may be struck. Immediately lie down in order that the effective fire may pass over.

If the troops are exposed to an oblique fire during the march they should conform to the movements indicated above, but having the men execute as much as possible an individual oblique to gain ground toward the right or left.

Retrograde march.—When infantry recedes from the enemy's artillery, the latter tries to encompass it, bring it within range and wait until it has passed beyond the over shots in order to deliver a rapid fire into the ranks; to escape this, the infantry should halt before crossing the point of fall of the over shots, or, what is impossible except with troops well-trained and well in hand. endeavor by a half-turn, neatly accentuated, to feign a return to the offensive. The object of this is to deceive the artillery and induce it to take new range. As soon as the shots fall short, the infantry will again take up the retrograde march. This maneuver dictated by good judgment, is complicated and delicate; we think it best not to attempt it, and to be satisfied with lying down very near the points of fall of the over shots, in order to allow the effective fire to pass beyond them.

Importance of the "prone" position.—One may see by all the preceding, the value of the "prone" position to infantry and the importance of our soldiers familiarizing themselves with it. But to take this position quickly, the respective position of the men in the ranks must be somewhat modified. Instead of separating them by a space of 12 centimeters only, or placing them elbow to elbow in the march by the flank, some space must be made between them. In a march by the flank, by twos, somewhat prolonged, especially in uneven ground, the files, instead of locking in marching, leave between each other some one or two paces, and sometimes more. If the men march thus in two ranks with a space of one pace between them, they can, at the first signal, lie down obliquely all together, packing up, so to speak, like sardines in a box.

The case of firing on marked zones.—If the artillery employs the method of firing on marked zones, as recommended by the manual, it is much more difficult for the infantry to escape the fire directed upon them by surprise. They must while marching avoid passing near points rendered conspicuous by their distance from similar objects, for instance an isolated group of trees, a wind-mill, cross road shrines, etc., and especially near a battery already in action with the opposing artillery. If it is necessary to cross a ridge, it is better to divide up as much as possible, even by half-sections with long intervals; the passage will be crossed company by company, afterward closing ranks again as soon as they are sheltered by the terrain, in order to reorganize the lines.

Probable losses caused by an effective fire.—To what losses will a company be exposed when surprised by the fire of a battery while traversing a visible terrain, marked in advance?

In one minute the German battery of 6 pieces will have been able to fire 48 shrapnel shell on three combined elevations of 100 meters, and thus sweep considering the depth of the sheaf, a zone 500 meters long by 150 meters wide, making 75,000 square meters. On this surface 14,400 balls will have fallen; that is to say, admitting a uniform mathematical distribution, less than one ball for 5 square meters. Now, a company of 200 men in line of half-section by the flank and by twos, presenting an assailable surface of less than 32 square meters, and one ball out of three being fatal, 6 to 7 balls at the most will fall on the troops, and 2 to 3 men only will be put hors de combat, if the company remains standing. The smoke from the bursting of 48 projectiles producing this small loss will conceal the troops and permit them to escape from this dangerous zone either by advancing or by moving by the flank; this second solution would be the better, for it would oblige the batteries of the enemy, in order to continue the fire, to execute a change of objective; this the German matériel renders very slow, but we must not lose sight of the fact that the troops whose march we have studied are marching with other troops in concert and in juxtaposition, and that their neighbors do not permit of this lateral change.

If the company has had the time to lie down, it decreased its vulnerable surface by two-thirds and its probable loss in proportion. In this position, indendently of the diminution of vertical surface, it must be remembered that the haversack protects the back of the foot soldier. It results in fact, from investigations made by General Langlois, that a haversack, carrying field supplies and struck squarely, resists in nearly all its parts, if the kinetic energy of the ball striking it is no more than 60 kilogram-meters; this corresponding to striking velocity of 300 meters, that is to say an aggregate velocity of shrapnel bullets exploding at a distance of 1,500 meters.

Infantry at short distances.—After having traversed a zone from 3,000 to 1,300 meters, our battalion, continuing its offensive march, finds itself exposed to the fire of both infantry and artillery. In this instance too, the employment of small columns of the flank, marching briskly, forming instantly into line and lying down at every halt, is preferable to any other formation. Nearer still, the firing line will remain in rank during the march, but all the echelons in the rear will retain the formation heretofore designated.

It must be observed in fact, that the enemy's artillery at these short ranges itself undergoes the fire of the infantry. The artillery fire, suffering thereby, is bothered moreover, by the very proximity of the friendly troops which run the risk of being struck. The guns are then absolutely obliged to direct their main fire against the reserves ; thus our first line has little more to suffer than the opposing musketry fire, which, at this moment, is equally distributed all along the front, the soldiers firing directly ahead without aiming at any definite objective.

It is during this period of the battle that the companies of the second line can, if the terrain where the attack is made permits of tiered fire, by long distance volley firing do damage to the battery and cause a confusion greatly interfering with the accuracy of pointing the guns.

Infantry remaining on the defensive.—In the defensive, the infantry line of battle is often obliged to remain tied down to one position and consequently loses all the advantages that it could obtain by an offensive movement. On the other hand, the infantry can profit by the slightest obstacles and re enforce them, thus lessening its liability to danger as well as its visibility. But if the line allows itself to be seen, especially behind cover such as woods and inhabited places, shelter more or less indicated on all the maps and easily known, then the artillery shall quickly adjust its fire to a narrow fork and shall execute a very accurate effective fire, either with shrapnel or high explosive shell. When the infantry occupies defensive shelter of this kind, it must, during the fire of the artillery, be careful to keep outside, availing itself of terrain, so as to mask itself from the enemy's sight ; entrenchments quickly made, even simple elevations formed by the setting up of haversacks, behind which the men lie down, will afford efficient protection. If, in spite of these precautions, the troops are discovered and must undergo the enemy's fire, they should not hesitate to endeavor to escape from the place by a flank movement executed as much as possible by round-about ways, so as to mislead the enemy.

During this tentative period, some scouts left on the outskirts of villages or woods to be defended in a position where they are little exposed on account of their small number and their dissemination, constantly furnish information regarding the enemy. When the infantry of the latter begins action, ours immediately occupies the border where it finds more or less protection depending upon the amount of rubbish and chips the enemy's artillery has made by its destructive fire.

PRECAUTIONS TO BE OBSERVED UNDER ARTILLERY FIRE.

Summing up, mobility, subdividing, and intelligent utilization of cover are the three means of which the infantry may avail itself to lessen the effects of the artillery. We firmly believe that it will accomplish its purpose to a great degree by:

1st. Marching in small columns with a narrow front, large intervals advancing according to the forms of terrain, disposed irregularly and almost checkerwise and especially avoiding a rigid alignment.

2nd, Crossing the line of points of fall at a rapid gait.

3rd. Increasing the distance between the lines, especially at the average distances of fire, and by echeloning the troops so that each line is placed beyond the sheaf of projectiles directed against the preceding line.

4th. Alternating rushes with halts behind obstacles suitably chosen.

5th. Taking the "prone" position, as briskly as possible when surprised by an effective fire, or when it is possible to foresee the firing of a volley by flash of the discharge.

6th. In order to execute the rushes by seizing the moment when, at the end of a "squall" for instance, the smoke of the bursting shells forms a veritable mask.

7th. When it is absolutely necessary to stand on open terrain, taking the "prone" position and using the haversacks for cover; never neglecting the construction of hasty entrenchments; it is greatly to be regretted, from this point of view, that the number of our hand tools should have been reduced as they were by the decision of July 4, 1896.

8th. Avoiding standing or passing near conspicuous points of terrain, which the German artillery will not have failed to mark.

These various recommendations which seem to be easily formulated, are in practice very difficult to carry out on account of the very parcelling out of the troops and the difficulty their chiefs will have in making them understand directions.

It is interesting to investigate the manner of training the troops conforming to these recommendations.

Let us consider the particular case of an officered battalion. This battalion assembled in a roll of ground in double normal column, and up to that time sheltered from the fire and out of sight of the enemy, receives the order to march on a position of the enemy provided with artillery.

The commander reconnoiters his objective and tries to form an exact idea of the nature of the ground in the sector where the troops are about to move. He places his battalion colors opposite this objective and indicates the two companies at the right and left of these colors to form the first line. In order to avoid every excuse not to maintain the same alignment, he gives to each of the captains a secondary objective wisely selected at the right and the left of the point of direction given to the flag.

These directions given, the battalion begins to march in double open column and so continues as long as masked by the terrain. As soon as the said battalion arrives within the zone of visibility, the sections take from each other as great a distance as possible (as much as 50 to 60 paces); the chiefs of sections give the order to march by twos with intervals; one of the sergeants marches at the head of the ranks, directed by the chief of section; the other sergeant takes post at rear, with instructions to close the troops in ranks as soon as possible, because this must be done to save the troops from unnecessary losses. As to the chief of section, he keeps at a distance of 20 to 30 paces in advance of his troops, in order to better observe the terrain, and to direct the march of his adjoining troops. For the first part of his duty, judging the terrain, he calls in the aid of his scouts in the following manner: two of these picked men, relieved of their haversacks which are first placed in the company wagon (for the weight burdens both the body and mind of a man), precede each section, not at a stated distance, but in a way to always precede it to the particular ground or obstacle suitable for a shelter; there, these two men, real "hooks" of their troops, halt, themselves taking up the "standing, kneeling, or lying position", as they may deem advisable. The section, leaving their former shelter, takes up the march toward them, directly in the footsteps of the chief preceding them; the latter follows the variations of the ground, in joining his scouts judges the value of the position which they have adopted, sends them out to a point ahead, then stops the troops when they reach him; he keeps them behind this obstacle until a new shelter is indicated by the scouts, and thus continuing to move. When they have entered the zone of musketry fire, the scouts, continuing as has just been described, take places apart in a way to take up a point in front of the section, which, stopping on their position, forms in line in one or two ranks in order to use their weapons.

When the terrain separating two consecutive shelters is completely open and greatly exposed to the artillery fire, the chief of section divides it into two half-sections, which, in order to cross the dangerous zone, march with a space of 25 to 30 meters, and again take up the march without regulating upon each other. Each sergeant, seconded by his two corporals, follows the lead of his chief, when the section is reunited.

The captain back of his four sections, does not lose sight of the adverse position and the fire illuminating it. When the points of fall encompass the company and presage effective fire, he gives a signal with a whistle, and all throw themselves on the ground, rising and marching ahead at the second whistle, given when the fire feared seems to have been executed. The captain acts in like manner when he is warned of the firing of a volley by the flash of the guns: at 2,500 meters, in fact, 8 or 9 seconds intervene between the discharge and the striking of a projectile, and troops marching by the flank, as we have already explained, can lie down in less than 6 seconds.

When the zone, which the company desires to pass, forces them to cross open terrain marked by points easy to distinguish at a distance, consequently surely noted by the opposing artillery, the captain communicates the facts to the chiefs of sections. He asks these chiefs to divide up their units as soon as possible and to have them cross the dangerous terrain successively in small groups and at a rate as rapid as the fatigue and loads of the soldiers may permit. The thick and stagnant smoke, coming from the bursting projectiles fired upon the fractions first exposed, greatly facilitates the march of the last groups if the latter lose no time in executing their movement.

On his part, the chief of battalion, allowing great elasticity to the movements of his companies of the first line, takes care that they do not deviate from their objective and that their advance march is in harmony with that of the neighboring battalions. so that they may reorganize and reform their line as soon as possible—that is, as soon as they find themselves sheltered from the fire.

The chief of battalion puts the companies of the second line in march which, advancing and observing the same precautions as the first line, avoids marching at the same time, being at least 300 meters behind. This distance, moreover, is not absolutely definite, but depends above all, on the formation of the terrain and may vary considerably, the two lines avoiding marching simultaneously, as much as possible.

When the relief of the ground and the distance permit, the fractions of the second line direct a volley fire on the batteries of the enemy while the first line advances; these volleys do damage to the artillery and deceive it as to the objective and render the finding of the range uncertain.

When the battalion has to cross dangerous parts where two companies can not separate their half-sections sufficiently to traverse this ground with the precautions indicated above, the commander shall stop one of the campanies on each line behind the last cover until the other has passed over.

Undoubtedly, an advance march to the fighting line executed in this manner, will be very slow, but there is nothing urgent. During this time the preliminary encounter takes place, and this indispensable phase, falling especially upon the artillery, under the protection of the infantry of the advance guard, will continue for some length of time. The essential point is to lead within close range of the enemy's positions, especially to the side where the encounter should take place, masses of troops which have suffered as little as possible. One can not excercise too many precautions to save them from losses. If they are brought almost intact over the artillery zone "De la mort", their moral force "always superior to physical force" says Marshal Bugeaud, who is a good authority on such matters, will have been increased ten-fold. One can then exact of the troops their maximum energy and audacity,—an energy and audacity imperiously demanded for the final effort.

Indeed, for the assault, these troops have before them not only some batteries still holding their position, but also troops of fresh infantry coming from the neighboring cover for the purpose of repulsing them, and posted in a manner to get full benefit of their modern arms.

In the face of musketry and artillery fire which is about to break loose and to be distributed almost equally all along the front, what formations should be employed? Those which are best adapted to the movement; for, if necessary, the troops must advance at any cost.

The first line of the arrangements in depth will be a deployed line, the men ready to fire, rushing by successive dashes and availing themselves of the least shelter of terrian during the short halts. All the other troops in the rear will be in line of small columns by the flank, in irregular groups, the bravest officers and soldiers at the head cheering on their comrades. Each line in rejoining the chain shall quickly form in deployed line and in a determined manner dash ahead.

Several lines will thus blend together until the assailant reaches the defender or compels him to retreat. But then it will be necessary to pursue him and probably to attack a second position, and for this duty, devolving upon the troops which have supported the first assault, the infantry must systematically take up again, under the protection of the artillery accompanying the attack, the formations recommended for the march of approach.

In review, notwithstanding all the qualities which the Germans attribute to their new artillery, we believe that the French infantry, as in the past, will be able to march under its fire, and will know how to do its duty under any circumstances incident to war. But for ail that, they mast not allow themselves to be influenced by the results of the drill grounds of our own artillery, which is superior to that of our neighbors; it is also necessary that the infantry should utilize all of their maneuvering qualities in a varied terrain, that it should accustom itself to count upon the co-operation of the other arms in the common objective, and that its moral education should always be inspired by the motto of our flags and standards.

These factors are of as much importance as the accuracy, and the velocity of the fire, the range and flatness of the trajectory of the field gun '96.

COMMANDANT DELIGNY,
of the 65th Regiment of Infantry.

UPON THE FORM OF THE HEAD OF OBLONG PROJECTILES WHICH ENCOUNTERS THE MINIMUM RESISTANCE TO MOTION FROM THE AIR.

[Reprinted from *La Corrispondenza.*]

(Concluded).

3. It is easy to conceive that it may not always be possible to find corresponding values in the table, which possess the desired relation between them; in such cases recourse must be had to interpolation. The necessary formulas for rendering such calculations expeditious are given below.

Let us assume, in the most general case, that $H = \mu$ calibers and that we have found in the table two values of $\frac{H}{c}$ between which lies the value sought. Let $\frac{H}{c}$ be the smaller of these values and let $\frac{r}{c}$ be the value corresponding to it in the second column.

Let Δ_1 be the difference between $\frac{H}{c}$ and the value sought, Δ_2 that between $\frac{r}{c}$ and the true value, and δ_1 and δ_2 the corresponding tabular differences, then we will have

$$\frac{H}{c} + \Delta_1 = 2\mu\left(\frac{r}{c} + \Delta_2\right)$$

$$\Delta_1 : \Delta_2 :: \delta_1 : \delta_2$$

from which we obtain

$$\Delta_1 = \frac{2\mu\frac{r}{c} - \frac{H}{c}}{1 - 2\mu\frac{\delta_2}{\delta_1}} \tag{15}$$

and

$$\Delta_2 = \frac{2\mu\frac{r}{c} - \frac{H}{c}}{\frac{\delta_1}{\delta_2} - 2\mu}. \tag{16}$$

Either of these expressions at once gives the value sought.

(a) For example, for $\mu = 0.5$, we find that $\frac{H}{c}$, from what has been said above, must lie between 9.56 and 10.63 (see table), hence

$$\delta_1 = 107,\ \delta_2 = 58, \text{ and } \Delta_1 = \frac{9.99 - 9.56}{1 - \frac{58}{107}} = 0.939$$

from which we obtain

$$\frac{1}{2c} = 9.56 + \Delta_1 = 10.499,$$

whence

$$c = 0.0476.$$

(b) For $\mu = 1$, we find that $\frac{H}{c}$ must lie between 63.45 and 67.68, hence

$$\delta_1 = 423,\ \delta_2 = 142, \text{ and } \Delta_1 = \frac{2 \times 31.91 - 63.45}{1 - 2 \times \frac{142}{423}} = 1.125$$

from which we obtain

$$\frac{1}{c} = 63.45 + \Delta_1 = 64.575,$$

whence

$$c = 0.0155.$$

(c) Finally, for $\mu = 1.5$, we find that $\frac{H}{c}$ must lie between 237.29 and 248.62, hence

$$\delta_1 = 1133,\ \delta_2 = 271, \text{ and } \Delta_1 = \frac{3 \times 80.01 - 237.29}{1 - 3 \times \frac{271}{1133}} = 7.39$$

from which we obtain

$$\frac{3}{2c} = 237.29 + \Delta_1 = 244.68,$$

whence

$$c = 0.00613.$$

4. The constant c having been found by the method indicated above, we immediately deduce r_0 from the relation $r_0 = 3.08\, c$, and, making use of the annexed table, we have a rapid means of calculating the generating curve of the head of minimum resistance by points. The column of $\frac{p_x}{c}$ gives the values of the trigonometrical tangents at the points considered, from which the direction of the curve at these points can be deduced.

With these criteria we have constructed the form of head represented in figure 2, the lenght of the head being 3 calibers.

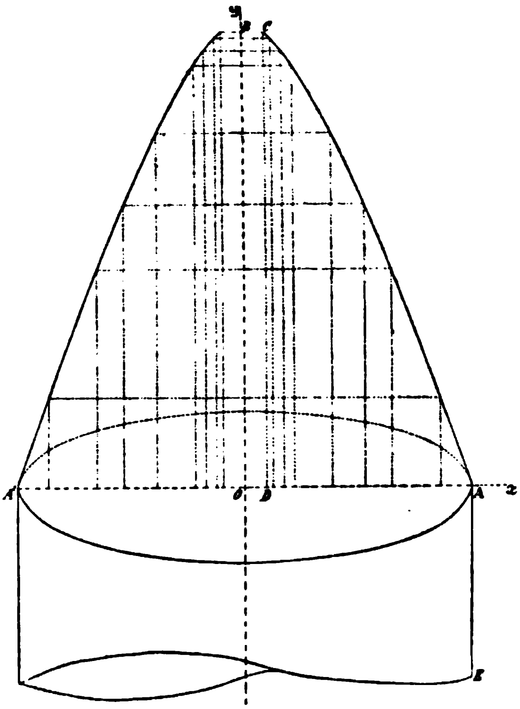

Fig. 2.

In this case we have (V. preceding §) $c = 0.0155$, whence $r_0 = 0.047$ calibers, from which the curve has been constructed by points, as indicated in the following table (the caliber has been taken as the unit of measure).

	$H = 1$ caliber							
$\frac{x}{c}$	4, 00	5, 56	7, 04	12, 50	17, 20	21, 02	27, 91	32, 29
$\frac{H-y}{c}$	2, 78	2, 60	4, 67	14, 34	24, 48	33, 66	51, 94	64, 58
x	0,062	0,086	0,109	0,193	0,266	0,325	0,432	0,500
y	0,987	0,959	0,927	0,778	0,621	0,478	0,196	0,000

We have thus solved, both analytically and graphically, the problem :

Given the length in calibers, to find the generating curve of the head of minimum resistance and the minimum aperture of the point.

But it is easy to see that the given formulas and the numerical table are equally adapted to the solution of the other and no less important problem :

Given the radius of the base and the aperture of the point, to find the length of the head of minimum resistance and to construct the generating curve.

In short, knowing r_0, we at once deduce c from the relation $r_0 = 3.08\ c$, then entering the second column of the table with the factor $\frac{r}{c}$ we find the corresponding value of $\frac{H}{c}$ whence we deduce H. The curve is then constructed in the manner just explained.

5. *Comparison between the different forms of head.* Up to this point we have discussed the analytical determination and graphical construction of the generating curves of minimum resistance, without giving a thought to the actual calculation of this resistance with a view to its comparison with that encountered by other forms of heads, as, for example, ogival, conical, and paraboloidal forms. In this paragraph, this question will be carefully considered and, in order to be able to make the above comparisons, we will express the resistance as a function of a dimension common to all heads of projectiles, the length of the head in calibers being selected for this purpose.

We have already seen that under the hypothesis of a direct resistance proportional to the square of the velocity, we can assume

$$R = \frac{2\pi r^2 b \Delta}{g} v^2 \int_{r_0}^{r} \frac{1}{r^2} \frac{x\,dx}{1 + y'^2}.$$

The factors of the second member which precede the integral depend upon the gravity and atmospheric conditions, upon the caliber and velocity of the projectile and upon an empirical coefficient of resistance ; hence this factor must remain the same for all projectiles to be compared. The integral, then, is the only factor in the above expression which will vary with the form of the head, and it is precisely these variations in its values, expressed as a function of the length of the head, common to all the projectiles considered, which furnish us the means of judging the magnitude of the resistance encountered by the projectile and hence of determining the greater or less advantage of the form of its head.

Let I indicate the integral $\frac{1}{r^2} \int_{r_0}^{r} \frac{x\,dx}{1 + y'^2}$, and let us consider the following forms :

(a) *Head of minimum resistance.* Having assumed (§ 2) $y' = -p$, we have from (5)

$$\frac{x}{1+y'^2} = \frac{c\,(1+p^2)}{p}$$

and also

$$dx = 4c\,(1+p^2)\left(1 - \frac{1+p^2}{4p^2}\right)dp$$

whence, substituting, and bearing in mind that for a minimum aperture of the point at the inferior limit, $p = \frac{1}{\sqrt{3}}$, we have

$$I = \frac{c}{r^2}\int_{\frac{1}{\sqrt{3}}}^{p_{\frac{r}{c}}} \left(3p^3 + 5p + \frac{1}{p} - \frac{1}{p^3}\right) dp,$$

and, performing the integration, we have

$$(17) \qquad I = \frac{c}{r^2}\left[\frac{3}{4}p^4_{\frac{r}{c}} + \frac{5}{2}p^2_{\frac{r}{c}} + L\,p_{\frac{r}{c}} + \frac{1}{2p^2_{\frac{r}{c}}} - 1.8673\right]$$

Examples. (1) If $H = r = 0.5$ calibers, we find (§ 3) $c = 0.0476$, $r_0 = 0.146$, and $p_{\frac{r}{c}} = 1.8438$, whence we have

$$I = 4\,c^2 \,.\, 16.0719 = 0.1457.$$

(2) If $H = 2r = 1$ caliber, we find $c = 0.0155$, $r_0 = 0.047$, and $p_{\frac{r}{c}} = 2.9633$, whence we have

$$I = 4\,c^2 \,.\, 79.0607 = 0.0774.$$

(3) If $H = 3r = 1.5$ calibers, we find $c = 0.0062$, $r_0 = 0.019$, and $p_{\frac{r}{c}} = 4.117$, whence we have

$$I = 4\,c^2 \,.\, 257.3308 = 0.0396.$$

(b) *Truncated conical head.* In this case the equation of the generatrix is the equation of the right line passing through the points (r_0, H) and $(r, 0)$, that is

$$y = \frac{H}{r - r_0}\,(r - x)$$

whence we obtain

$$1 + y'^2 = 1 + \left(\frac{H}{r - r_0}\right)^2$$

and hence we have

$$(18) \qquad I = \frac{1}{r^2}\int_{r_0}^{r} \frac{x\,dx}{1 + \left(\frac{H}{r - r_0}\right)^2} = \frac{1}{2r^2}\,\frac{r^2 - r_0^2}{1 + \left(\frac{H}{r - r_0}\right)^2}.$$

Examples. (1) If $H = r = 0.5$ calibers, r_0 being 0.146, we have

$$I = 0.1527.$$

(2) If $H = 2r = 1$ caliber, r_0 being 0.047, we have

$$I = 0.0843.$$

(3) If $H = 2r = 1.5$ calibers, r_0 being 0.019, we have

$$I = 0.0465.$$

(c) *Truncated parabaloidal head.* The equation of the parabola passing through the two points r_0, H) and $(r, 0)$, referred to the usual axis Ox and Oy, and having its origin at the center of the base of the head and the axis Oy coincident with the principal diameter of the parabola, is as follows,

$$x^2 = r^2 - 2my$$

in which we have assumed for brevity

$$m = \frac{r^2 - r_0^2}{2H}.$$

It is evident that

$$y' = -\frac{x}{m}$$

and therefore we have

$$I = \frac{1}{r^2} \int_{r_0}^{r} \frac{x\,dx}{1 + \frac{x^2}{m^2}} = \frac{m^2}{2r^2} L \frac{r^2 + m^2}{r_0^2 + m^2}. \tag{19}$$

Examples. (1) If $H = r = 0.05$ calibers, r_0 being 0.146, we find

$$I = 0.0493.$$

(2) If $H = 2r = 1$ caliber, r_0 being 0.047, we find

$$I = 0.0834.$$

(3) If $H = 3r = 1.5$ calibers, r_0 being 0.019, we find

$$I = 0.0493.$$

(d) *Truncated ogival head.* The equation of the circle passing through the two points (r_0, H) and $(r, 0)$, referred to the usual system of rectangular axes Ox and Oy, and having its origin at the center of the base of the ogive is as follows:

$$(x + R - r)^2 + y^2 = R^2$$

in which R is the radius of the circle, given by the relation

$$R = \frac{r - r_0}{2}\left(1 + \frac{H^2}{(r - r_0)^2}\right).$$

It is evident that

$$1 + y'^2 = \frac{R^2}{R^2 - (x + R - r)^2}$$

whence we obtain

$$(20) \qquad I = \frac{1}{r^2}\int_{r_0}^{r}\left[1 = \frac{(x+R-r)^2}{R^2}\right] x\,dx = \frac{1}{12\,R^2\,r^2}\left[4\,R\,(r^3 - r_0^3) - (r^4 - r_0^4)\right].$$

Examples. (1) If $H = r = 0.5$ calibers, r_0 being 0.146, we find $R = 0.5301$ and

$$I = 0.233.$$

(2) If $H = 2\,r = 1$ caliber, r_0 being 0.047, we find $R = 1.3301$ and

$$I = 0.1134.$$

(3) If $H = 3\,r = 1.5$ calibers, r_0 being 0.019, we find $R = 2.5794$ and

$$I = 0.0615.$$

(e) *Ogival head of minimum resistance.* In what precedes, we have assumed that the center of the generating arc of the ogive is in the plane of its base, that is, that the cylindrical body of the projectile is tangent to the ogive, but this condition is not essential, it being also possible to place the center in question in a plane below that of the base, as is the case with many projectiles in use. It is evident that in order to make an accurate comparison (relative to the resistance encountered) of the different forms of heads with that of the ogive, the position of the center can not be neglected, as the variation of the latter, which also varies the curvature of the ogive, varies the resistance which the projectile encounters in its motion. We have therefore thought it would not be wholly without interest to complete our research by the determination of the ogive of minimum resistance, or, more exactly, by the solution of the problem:

Given the radius of the base and the length of the head of the projectile, to find the ogive which will encounter the minimum resistance to motion in air.

Let the generating arc of the ogive, which must pass through the points (r_0, H) and $(r, 0)$*, be referred to the usual rectangular axes Ox and Oy, and let λ and ν be the coordinates of the origin O, with reference to two parallel axes drawn through the center of the arc. Then, R being the radius of the arc, its equation will be

$$(x + \lambda)^2 + (y + \nu)^2 = R^2,$$

and since this must pass through the points (r_0, H) and $(r, 0)$, we will have

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* The truncated ogive was assumed in order to discuss the most general case; to obtain the pointed ogive we merely place $r_0 = 0$.

$$(r_0 + \lambda)^2 + (H + \upsilon)^2 = R^2$$

and

$$(r + \lambda)^2 + \upsilon^2 = R^2,$$

whence, eliminating υ, we obtain.

$$R^2 = \left[1 + \left(\frac{r - r_0}{H}\right)^2\right] \left[\left(\lambda + \frac{r - r_0}{2}\right)^2 = \frac{H^2}{4}\right].$$

From the above we readily obtain

$$I = \frac{1}{r^2} \int_{r_0}^{r} \frac{x\,dx}{1 + y'^2} = \frac{1}{r^2} \int_{r_0}^{r} \left[1 + \frac{(x + \lambda)^2}{R^2}\right] x\,dx$$

from which, performing the integration, and substituting for R its value in terms of λ, we obtain

$$I = \frac{s^2}{r^2} = \frac{s_4 + 2\,s_3\,\lambda + s_2\,\lambda^2}{r^2\left(1 = \frac{s_1^2}{H^2}\right) \cdot \left(\frac{H^2}{4} + s_0^2 + 2\,s_0\,\lambda + \lambda^2\right)}$$

in which we have assumed, for brevity

$$s_4 = \frac{r^4 - r_0^4}{4},\ s_3 = \frac{r^3 - r_0^3}{3},\ s_2 = \frac{r^2 - r_0^2}{2},\ s_1 = r - r_0,\ s_0 = \frac{r + r_0}{2}.$$

We must now determine λ with the condition that the ogive be of minimum resistance, and hence must place the derivative of I with respect to λ equal to zero. This being done, we obtain the quadratic equation

$$(s_3 - s_0\,s_2)\,\lambda^2 - \left[s_2\left(\frac{H^2}{4} + s_0^2\right) - s_4\right]\lambda - s_3\left(\frac{H^2}{4} + s_0^2\right) + s_0\,s_4 = 0$$

of which the third term is negative. It is evident that the roots of this equation are real and of contrary sign, and since it can not be negative, λ will be determined by the single positive root of the equation.

The value of λ having thus being found. that of R immediately follows, and will be the radius of the ogive of minimum resistance. In order, then, to obtain the value of the resistance encountered by this ogive, it will suffice to substitute for λ its value and calculate I, which, as we know, is one of the factors of the resistance in question.

Examples. (1) If $H = r = 0.5$ calibers, r_0 being 0.146, we find $\lambda = 1.3235$, and

$$I = 0.1468.$$

(2) If $H = 2\,r = 1$ caliber, r_0 being 0.047, we find $\lambda = 3.4811$ and

$$I = 0.078.$$

(3) If $H = 3\,r = 1.5$ calibers, r_0 being 0.019, we find $\lambda = 7.0372$ and

$$I = 0.042.$$

In order to better illustrate the different manner of behavior of the different forms of heads of projectiles opposed to the resistance of the air, we have collected the examples already discussed, together with some others, in the following table.

Length of head H in calibers.	Radius of the point r_0 in calibers.	Values of $(10^4)\,I$ for various projectile heads, thus					Remarks for ogival projectiles.
		Conical	Parabaloidal	Ogival	Ogival of minimum resistance	Minimum resistance	
0.5	0.146	1527	1481	2330	1468	1457	
1	0.047	843	834	1134	780	760	
1.3229	0.025	574	587	798	516	499	Krupp projectiles.
1.5	0.019	465	493	615	420	393	Hotchkiss "
1.75	0.008	356	395	488	323	309	Canet "

From the above, we see clearly how the various forms of heads of projectiles are classified and how, leaving the length of the head unaltered, we can diminish the resistance by changing its form.

A. BASSANI.

[Translated by Captain Frank E. Harris, Artillery Corps.]

EXPERIMENTS IN ILLUSTRATION OF THE TOP-MOTION OF ROTATING OBLONG PROJECTILES.

By Albert Edler v. Obermayer,
Colonel, Austro-Hungarian Army.

Reprinted from *Mittheilungen über Gegenstände des Artillerie und Genie-Wesens.*

(Concluded.)

ROTATION OF A BODY ABOUT A POINT DUE TO IMPULSIVE FORCES. POINSOT MOTION.

When a body rotates about its center of gravity under the action of impulsive forces, the principle of the invariable plane or the principle of areas, is applicable. This principle states that the moment of momentum of a rotating body left to itself is constant, and that the axis of such moment of momentum retains the same direction in space. According to the notation previously employed, this proposition means that the impulse vector of rotation is constant in direction and magnitude.

The plane perpendicular to the impulse vector retains, therefore, its direction in space, and is called the plane of the moment of momentum or the invariable plane.

Whilst, however, the impulse vector thus retains a constant direction in space, the instantaneous axis of rotation and the rotation vector continually change both their direction and magnitude.

Through an exceedingly ingenious and simple construction, Poinsot has sought to discover the rotation vector corresponding to every position of the impulse vector in the movable system. He accomplished this by means of the momental ellipsoid of the center of gravity, the so-called first central ellipsoid. The latter may be defined as the locus of all points that are at a distance from the center of gravity equal to the reciprocal of the square root of the moment of inertia of the body with respect to the line upon which this distance is laid off. This central ellipsoid is generally one of three unequal axes, called the principle axes of inertia of the body at the center of gravity.

If the principle axes of inertia and the principle moments of inertia are given, thus, $A < B < C$, the semi-diameters of the first central ellipsoid are deduced as follows:

$$a_0 = \frac{1}{\sqrt{A}}, \quad b_0 = \frac{1}{\sqrt{B}}, \text{ and } c_0 = \frac{1}{\sqrt{C}},$$

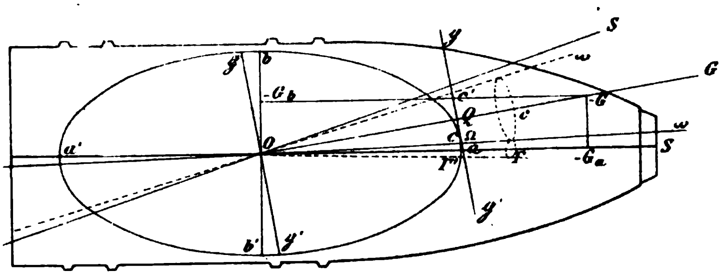
from which we obtain, $a_0 > b_0 > c_0$.

When $A < B$ and $B = C$, the central ellipsoid is a prolate spheroid, when $C > B$ and $B = A$, the central ellipsoid is an oblate spheroid and when $A = B = C$, the central ellipsoid is a sphere.

For an ellipsoid whose semi-diameters bear the relation $a:b:c = 7:5:1$, or for a parallelepipedon whose sides bear the same relation, the relation of the semi-diameters of the central ellipsoid is found to be $a_0:b_0:c_0 = 13.9:10.0:8.2$,* so that the smallest and greatest dimensions of the central ellipsoid fall upon upon the smallest and greatest dimensions, respectively, of the body.

The central ellipsoid is conceived as fixed within the body. If the impulse vector is drawn in the right position with reference to the body, and a plane perpendicular to the impulse vector and tangent to the ellipsoid be drawn, the point of tangency thus determined will be the pole of the instantaneous axis of rotation, i. e., the right line about which the rotation begins.

Fig. 6.



In fig. 6, as an example, the central ellipsoid *a b a' b'* is drawn in the 8 cm. shell M. 1875. If *O G* is the direction of the impulse vector, i. e., the axis about which the moment of impulsion acts, the projectile does not begin its rotation about this direction. The instantaneous axis of rotation passes through the point of tangency Ω, of the tangent plane perpendicular to *O G*.

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* The movements of inertia of a spheroid with respect to central principal axes are as follows:

$A = M\frac{b^2+c^2}{5}$, $B = M\frac{a^2+c^2}{5}$ and $C = M\frac{a^2+b^2}{5}$. Substituting for *a*, *b*, and *c* their values as assumed above we have $A = M(5.2)$, $B = M(10.)$, and $C = M(14.8)$.

But $a_0 = \frac{1}{\sqrt{A}}$, $b_0 = \frac{1}{\sqrt{B}}$ and $c_0 = \frac{1}{\sqrt{C}}$.

$\therefore\ a_0 = \frac{1}{\sqrt{M(5.2)}}$, $b_0 = \frac{1}{\sqrt{M(10)}}$ and $c_0 = \frac{1}{\sqrt{M(14.8)}}$.

$$\therefore\ a_0 : b_0 : c_0 = \frac{1}{\sqrt{5.2}} : \frac{1}{\sqrt{10}} : \frac{1}{\sqrt{14.8}} = \sqrt{\frac{1000}{5.2}} : \sqrt{\frac{1000}{10}} : \sqrt{\frac{1000}{14.8}} = 13.9 : 10. : 8.2.$$

Tr.

On the contrary, should the projectile be found to rotate about the direction O ω, a moment of an impulsion must be acting about the direction *O G*.

Only in case of coincidence of the impulse vector with a principle axis of inertia, as, for example, with *O S*, would the rotation also begin about *O S*.

In the central ellipsoid, the instantaneous axis of rotation is the conjugate diameter to the invariable diametral plane $\mathfrak{G}\,\mathfrak{G}'$, perpendicular to the impulse vector.

The subsequent course of the motion of the system is represented by the rolling, without sliding of the central ellipsoid upon the invariable plane, at the constant distance h, of the latter, from the center of gravity of the central ellipsoid.

The line traced by the point of tangency upon the surface of the central ellipsoid is called the polhode. A right line through the center of gravity and moving on the polhode describes the cone of the polhode and gives the position of the instantaneous axis of rotation in the system.

The line traced by the point of tangency upon the invariable plane is called the herpolhode. A right line through the center of gravity and moving on the herpolhode describes the cone of the herpolhode and gives the consecutive positions of the instantaneous axis of rotation in space.

During the rolling of the central ellipsoid upon the invariable plane, the cone of the polhode likewise rolls, without sliding, upon the cone of the herpolhode.

The instantaneous angular velocity varies directly with the length of the semi-diameter of the momental ellipsoid which coincides with the instantaneous axis.

In order to obtain the graphs of the polhode and herpolhode, I had an apparatus* constructed for the Physical Cabinet of the Austro-Hungarian Technical Military Academy, consisting of three semi-ellipsoids with semi-diameters bearing the relation 13.9 : 10.0 : 8.2, which could be located at a definite height above a fixed sooted plate; the ellipsoids could be made to roll by means of suitable connections and would thus trace the curves sought.

In the case of projectiles, two of the axes of the momental ellipsoid are equal, these being always the axes of greatest and mean moments of inertia. The central ellipsoid is a prolate spheroid of revolution and the polhode and herpolhode are circles;

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* "Experimental Demonstration of Poinsot's Theory of Rotation", Carl. "Repertory of Physics". A Manual of Physics for Instructors at the Austro-Hungarian Technical Military Academy, page 296.

the latter can therefore, be represented without the assistance of special apparatus.

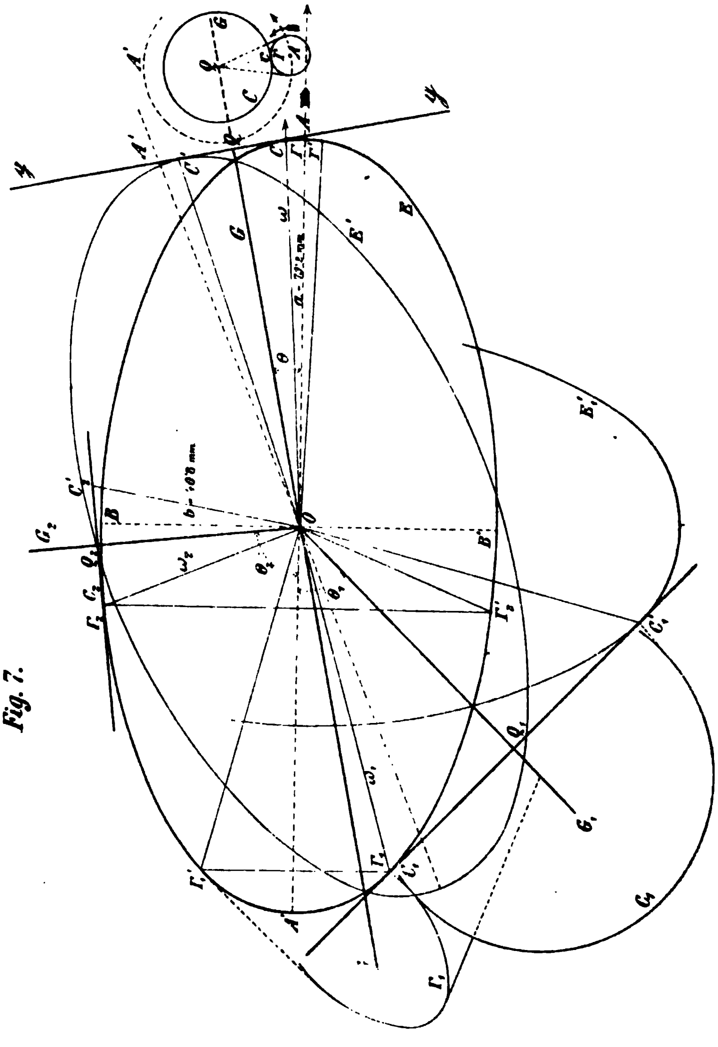

Fig. 7.

Fig. 7 shows the central ellipsoid for the 9 cm. shell M. 1875, constructed from the values for the moments of inertia previously determined, thus,—

$$a = \frac{1}{\sqrt{A}} = \frac{1}{\sqrt{63873}} = 0.003957,$$

$$b = \frac{1}{\sqrt{B}} = \frac{1}{\sqrt{240401}} = 0.002039.$$

As it is a question simply of the ratio of these semi-diameters, their values will be taken as follows:

$$a = 7.92 \text{ cm. and } b = 4.08 \text{ cm.}$$

Let fig. 6 represent the horizontal projection of a projectile fired with its axis horizontal.

In order to avoid making the construction towards the rear of the projectile, and contrary to the usual convention, all rotations, axes and impulse vectors, are laid off in a direction such that the motion viewed from it, is contrary to that of the hands of a clock.

Should the projectile on leaving the muzzle rotate accurately about its geometrical axis, the invariable plane would be perpendicular to the axis $O\,A$ of the central ellipsoid and the impulse and rotation vectors would coincide.

Should the projectile on leaving the bore, experience an impulse which rotates the base of the projectile upwards about a horizontal transverse axis, the corresponding impulse vector G_b, laid off to the left, must be combined with the impulse vector $-G_a$, according to the rule of the parallelogram of forces; the resultant impulse vector or moment of momentum $-G$ is thus determined. The invariable plane $\mathfrak{G}\,\mathfrak{G}'$ is drawn tangent to the central ellipsoid and perpendicular to this impulse vector. $O\,C$ is the instantaneous axis of rotation, i. e., the axis about which the rotation begins, $O\,Q = h$, is the invariable plane from the center of gravity of the central ellipsoid.

If $Q\,C' = Q\,C$, then $C\,O\,C'$ is the horizontal projection of the cone of the herpolhode; similarly, if $A\,\Gamma = A\,\Gamma'$, $\Gamma\,O\,\Gamma'$ is the horizontal projection of the cone of the polhode.

Both these cones are circular; their projections on the plane $\mathfrak{G}\,\mathfrak{G}'$ are accurately represented in the figure, to the right of the trace of said plane. The cone of Γ rotates, in the first instant about the coincident right lines $Q\,C$ and $Q\,\Gamma$, in a direction opposite to that of the hands of a clock, and rolls, without sliding, on the outside of the cone of C, likewise in a direction opposite to that of the hands of a clock. The projectile point is carried around upon the circle $A\,A'$ in a direction opposite that of the hands of a clock; this circle lies wholly to the left of the vertical plane through the axis of the bore, so that under the circumstances here supposed, the point of an oblong projectile moving in a vacuum would always remain to the left of the vertical plane through the axis of the bore. $E'\,C'\,A'$ represents the central ellipsoid in its extreme position to the left.

Since the cone of the polhode is here a circular cone, the radii-vectors of the central ellipsoid, which vary directly with the instantaneous angular velocities, are the same length; the instantaneous axis of rotation and the axis of the projectile rotate with uniform velocity about the impulse vector G, having the direction $O\ Q$.

Klein and Sommerfeld in their oft cited work entitled "On the Theory of Tops", page 127, designate such a motion as regular precession.

If we conceive the rotation vector projected on the axis of figure, such projection would have the same value throughout the entire time of motion; the projectile, therefore, rotates uniformly with reference to its axis of figure, thus exhibiting the characteristic of regular precession.

The Poinsot motion (motion under the action of impulsive forces) of rotating oblong projectiles is their motion of oscillation called regular precession, in contradistinction from the motion of the projectile about its center of gravity under the action of the moment of resistance of the air, which is called pseudo-regular precession.

If a wooden model of an ogival headed, cylindrical projectile, be suspended from a centrifugal engine by means of a hook at the end of its geometrical axis, and then set in rotation, it is well known that the motion will develop into a rotation about a transverse axis owing to the perturbations arising from imperfections in the suspension hooks.

This occurence is illustrated in fig. 7 by two constructions. Taking G_1 as the impulse vector, C_1 and Γ_1 are the corresponding cones of the herpolhode and polhode; the openings of both cones at first increase with θ_1, later, however, the opening of the cone of C begins to diminish while that of the cone of Γ continues to increase. The latter condition is shown at the impulse vector G_2. Finally, the cone of C becomes a right line and the cone of Γ a plane rotating about one and the same right line within its surface. The change to rotation about a transverse axis is thus complete.

THE OSCILLATION OF OBLONG PROJECTILES IN THE ATMOSPHERE.

During the Poinsot motion, or the oscillation of rotating oblong projectiles in vacuum, the impulse vector always retained its magnitude and direction unchanged, and in case of right handed rotation, its negative end (i. e., the end in the direction of flight) was initially somewhat to the left of the vertical plane through the axis of the bore.

Should the openings of the cones of the polhode and herpolhode, which, in motion under the action of impulsive forces, define the regular precession, be very small, the phenomenon resulting would be accurately represented by fig. 5.

The moment of resistance of the air varied the direction of the impulse vector of the projectile but not its length; the effect of this was to cause the projectile, during its motion of oscillation, to move its point upwards and to the right, i. e., to adopt a pseudo-regular precession.

The axis of the projectile will describe instead of pointed epicycloids, a kind of elongated spherical ones. The pseudo-regular and regular precessions are combined. The oscillations are executed very quickly but predominate to the right of the vertical plane through the axis of the bore; the resistance of the air urges the projectile to the right of the above plane.

The oscillation of the projectile produces a periodic variation in the direction of the line of nodes, due to the equatorial plane being carried along with the oscillation. The increments of the impulse vector fall in the direction of the line of nodes and vary their magnitude and direction with it. The motion of the resultant impulse vector in space takes place with a periodic variable velocity; the whole phenomenon is really much more complicated.

The center of gravity of the projectile, owing to the varying direction of the resistance of the air, is generally, it is true, urged to the right, but with a periodically varying velocity.

Since the geometrical axis of the projectile is the axis of the least moment of inertia, the periodic influences of the resistance of the air have a tendency to continually remove the instantaneous axis of rotation farther from the geometrical axis, as was shown with reference to the perturbations in the experiments with the centrifugal engine previously cited.

The effect, therefore, of the resistance of the air, is to open out the cones of the polhode and herpolhode in the course of the projectile's motion, and leads to the change from a rotation about the geometrical axis to that about a transverse axis.

The phenomenon designated as the oscillation of the projectile is the result of an impulsion which the projectile suffers on leaving the bore; this phenomenon would result, similarly, in a vacuum. It is modified by the resistance of the air, under whose influence it exhibits the gradual change to rotation about a transverse axis.

The frequently cited observation of Rutzky that the point of an illuminating shell describes, during flight, a spiral which increases with the distance traversed by the projectile,—a fact most clearly perceived by the smoke of the flame issuing from an opening contrived in the base of the projectile—may be regarded as a voucher in support of this view.

The rate at which the perturbating influences cause the change to a rotation about a transverse axis is to be determined from a stability factor. The stability factor adopted by Cranz* is

$$\frac{A^2 r^2}{4 B . M}$$

in which A is the moment of inertia about the geometrical axis, B that about a transverse axis through the center of gravity, M the moment of resistance of the air and r the angular velocity. Designating the stability by σ and introducing therein the ratio $B : A$, the above expression becomes

$$\sigma = \frac{A r^2}{4 \cdot \frac{B}{A} \cdot M},$$

from which we see that the stability factor is directly proportional to the moment of inertia about the geometrical axis and inversely proportional to the ratio of the greatest to the least moment of inertia.

The opening of the small cone of the polhode (cone of Γ in the system, half amplitude of the nutation vibration) is, moreover, proportional to the quotient $B : A^2 r^2$; consequently, the nutation motion of the geometrical axis, due to the pseudo-regular precession, is directly proportional to the ratio of the greatest to the least moment of inertia and inversely proportional to the least; the opening of the cone of nutation is, therefore, inversely proportional to the factor of stability. The factors $A^2 : B$ for the various models and projectiles, whose moments of inertia have been calculated, are given in the following table:

	A	$B : A$	$A^2 : B$
Original model of Magnus	950	2.55	372
Model II	4572	6.94	659
Model I	4895	1.98	2469
9 cm. shell M. 1863	34481	2.53	13772
9 cm. shell M. 1875	63873	3.76	16972
8 mm. Mannlicher projectile	1.264	11.16	0.1132

The calculations for the Mannlicher projectile were based on the assumption that the projectile was a cylinder of length $l = 3.2$ cm., radius $r = 0.4$ cm. and weight $M = 15.8$ g.

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* Compendium of Theoretical Ballistics, page 272.

By means of the principle of similitude it is possible to make a very simple comparison between the factors of stability of the different models. This principle asserts that in similar mechanical systems, the forces and moments are directly proportional to the fourth and fifth powers respectively, of the linear dimensions, and are inversely as the square of the times in which the systems execute their motions.

For the same number of turns and same wind velocity, the moment M of the original model of Magnus will be $(90 : 112.6)^5$ times that of model I. The factor $A^2 : B = 372$, of the Magnus' model must, therefore, be multiplied by $(112.6 : 90)^5$ to give the stability factor for comparison with that of model I. This product is 1142, about half that of model I, which is 2469. The greater model appears to have somewhat the advantage.

For the same number of turns, model I has a stability nearly 63 times as great as that of model II. This number, however, is subject to considerable doubt owing to the difference in form of the two models.

A comparison between the 8 mm. Mannlicher projectile for which $A^2 : B = 0.1132$ and the 9 cm. shell M. 1875 for which $A^2 : B = 16972$ can only be made by taking into consideration the order of the magnitudes entering the stability factor. In this case, as the number of turns of the two projectiles is not the same, the difference must be taken into consideration in applying the principle of similitude.

Assuming that the 9 cm. shell makes 111.9 rotations per second, its stability factor will be proportional to the product $(16972 \times 111.9^2) = 212{,}400{,}000$.

The Mannlicher projectile makes 2480 rotations per second, is but $\frac{2}{15}$ the length of the shell, and has a velocity of 620 m./sec. as against 438 m./sec. for the shell.

Since the times in which motions are executed are inversely proportional to the velocities, the moment of resistance of the air for the shell must be multiplied by the factor

$$\left(\frac{2}{15}\right)^5 \cdot \left(\frac{438}{620}\right)^{-2}$$

in order to deduce therefrom that for the Mannlicher projectile. It is evident that the value thus obtained is only relative.

The stability factor for the Mannlicher projectile is therefore proportional to the following product:

$$0.1132 \times 2.480^2 \times 7.5^5 \times (438 : 620)^2 = 8{,}250{,}000{,}000.$$

This value is 38.8 times greater than that for the shell, whereas the ratio $A^2 : B$ for the Mannlicher projectile is but 1/150,000 part of that for the shell.

Although very strong objections can be made against the admission of such comparisons, because the similitude existing between the projectiles is incomplete, and because the resistance of the air varies with the velocity in a complicated manner, they yet show, that notwithstanding the great difference between the factors $A^2 : B$, the values of the stability factors are not too greatly separated.

I purposely refrain from making comparisons between actual and model projectiles, because of the undoubted presence of a wind effect upon the rings of the latter.

One more observation should here be added. Heavy tops, supported at the center of gravity, have usually been employed to show that the axis of a rotating body deviates perpendicular to a force acting towards the axis. The same result is obtained with the revolving rings in constrained motion gyroscopes. These revolving rings are suspended with a single rotating ring in a fixed ring, and make it possible to impart to a body rotating about its geometrical axis, (a principle axis of inertia) another rotation about a second axis. With this apparatus it was shown, that the positive end of the axis of rotation so moved towards the positive end of the new axis of rotation, that the axes became parallel and the rotation about both was in the same direction.

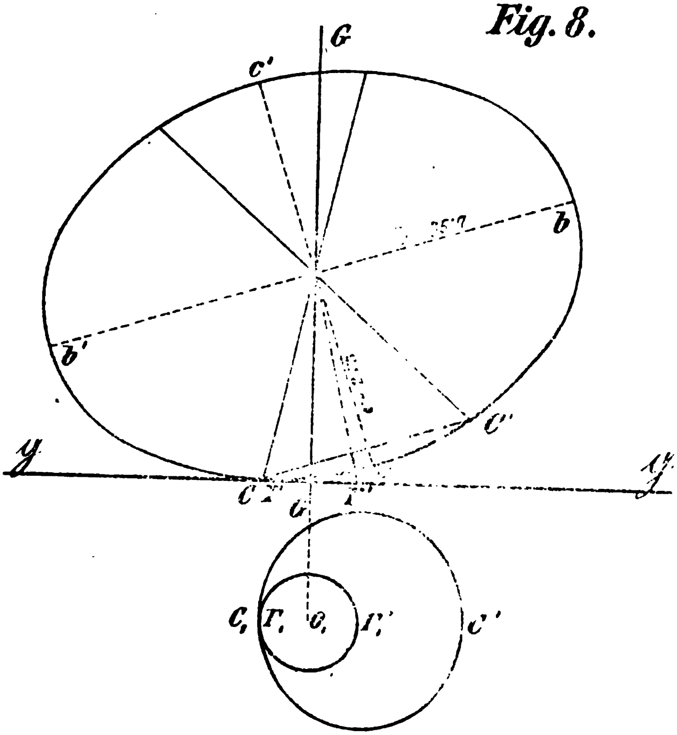
In this apparatus, the central ellipsoid is generally an oblate spheroid and the geometrical axis generally that of the greatest moment of inertia. For a revolving ring having an external diameter of 12 cm., and a circular cross section of 1.4 cm. radius, attached, by means of a thin disc, to a hollow axis 2.8 cm. long mounted on a steel axle, the mass of the system being 1709 g., the moments of inertia were found to be as follows :

About the geometrical axis.....$C = 36325$ g^1 cm.^{2},
About a transverse axis............$B = 19606$ g.^{1} cm.^{2}
From the above we obtain .....$C^2 : B = 67320$, quite a large ratio.
The semi-diameters of the momental ellipsoid are $c = 26.3$ and $b = 35.7$.

The axis is so stable during rotation that it is scarcely possible for an impulse to impart to it a motion of regular precession.

These bodies show quite a different kinetical relation from those whose momental ellipsoids are prolate spheroids. Such a

Fig. 8.



central ellipsoid is shown in fig. 8; $G O G$ is the direction of the impulse vector. The invariable $\mathfrak{G}\,\mathfrak{G}'$ is perpendicular to the impulse vector and tangent to the central ellipsoid at C; $O C$ is the rotation vector, $C O C^1$ the cone of the polhode and $\Gamma O \Gamma^1$ that of the herpolhode. The projections of both cones on the plane $\mathfrak{G}\,\mathfrak{G}'$ are shown in the figure below the trace of said plane.

The cone of the polhode, in this case, under the action of impulsive forces, i. e., under a motion of regular precession, moves round upon the cone of the herpolhode, thus executing a pericycloidal motion.

The tendency of the instantaneous axis of rotation to withdraw from the principal axis of inertia, does not exist in bodies whose central ellipsoids are oblate spheroids and whose rotation takes place about their axes of greatest moments of inertia; on the contrary, perturbations induce here rather an approach of the instantaneous axis of rotation to the principal axis of inertia.

[Translated by Captain Frank E. Harris, Artillery Corps.]

PROFESSIONAL NOTES.

ARTILLERY MATERIAL.

Test of Conical and Cylindrical Breech Blocks by Bethlehem Steel Company South Bethlehem, Pa., U. S. A.

Bethlehem Steel Company, January 1900.

Hydraulic Tests of Conical and Cylindrical Breech Plugs.

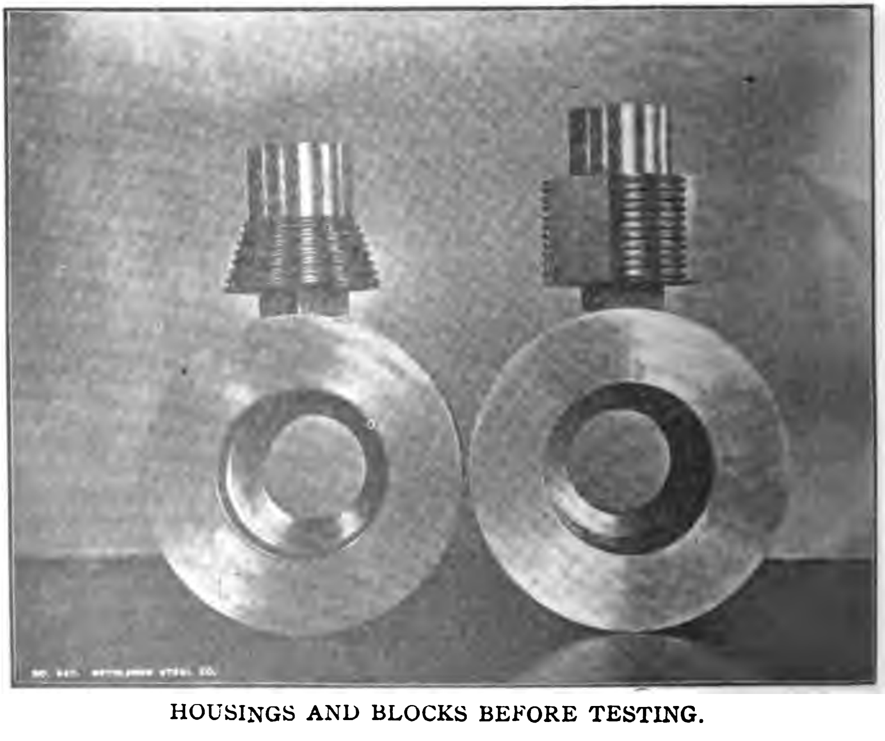
First Test	Length	Diameter Rear	Front	Threaded area	Weight of threaded portion in pounds.
Conical Plug	1.5 in.	3 in.	2 in.	11.78	2.12
Cylindrical "	2. in.	3 in.	3 in.	9.4	4.

A load of 350,000 pounds corresponding to 112,500 pounds per square inch of powder pressure was applied without injury to either plug.

Second Test	Length	Diameter Rear	Front	Threaded area	Weight of threaded portion in pounds.
Conical Plug	1.5 in.	3 in.	2 in.	11.78	2.12
Cylindrical "	1.5 in.	3 in.	3 in.	7.05	3.

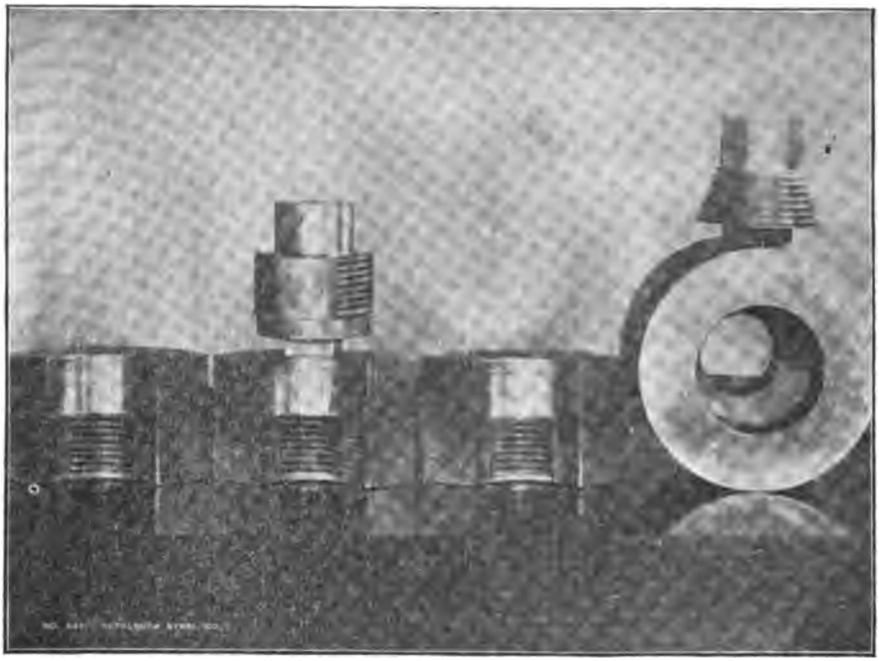
The conical plug was again subjected to the load of 350,000 pounds without injury, while the cylindrical thread sheared under a load of 340,000 pounds corresponding to a pressure of 108,000 pounds per square inch in powder chamber.

Accompanying Report of January 1900.



HOUSINGS AND BLOCKS BEFORE TESTING.

ACCOMPANYING REPORT OF JANUARY.



HOUSINGS AND BLOCKS AFTER TESTING.
(Housing for cylindrical block cut through to show shearing of thread).

ANALYSIS OF RFPORT OF FEBRUARY 1900.

March 6, 1900.

Mr. R. W. Davenport,
General Superintendent.

Dear Sir :-

I send you two copies of the test of Conical and Cylindrical Breech Blocks, undertaken to determine the value of the new Bethlehem Conical continously threaded breech block, compared with the breech blocks of the existing types of interrupted cylindrical threads; the claims for the new breech block being, that it is stronger and will open and close with greater ease than a cylindrical block of the same weight.

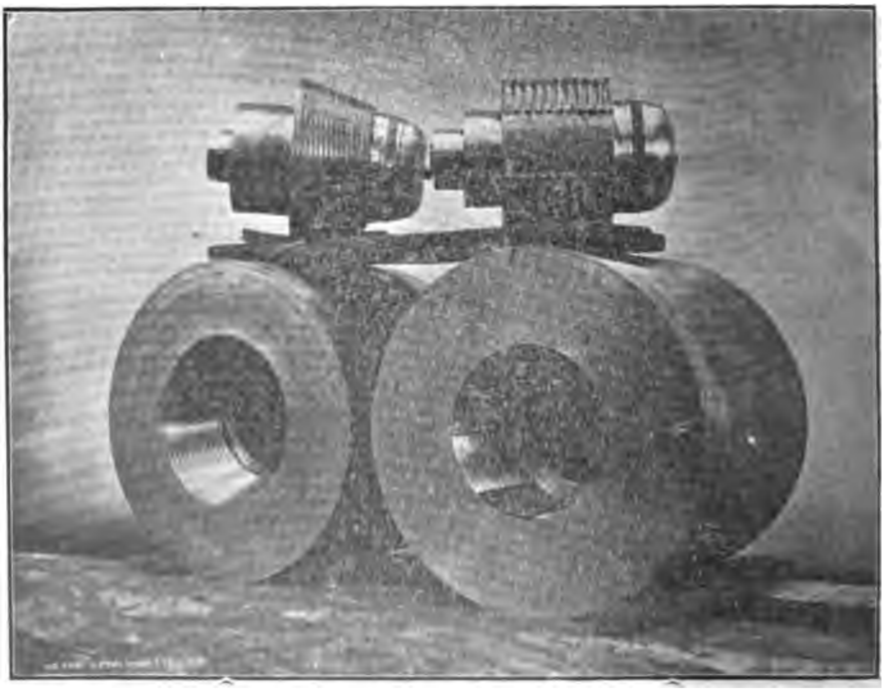
The plugs tested were the standard plug for the 5-inch U. S. Army gun, a plug of more than ordinary strength and the conical plug of the Bethlehem 5-inch gun. These plugs were first tested as far as the strength of the gun would allow, then one half of the threaded area was removed from each plug, as shown on photograph and the test continued to destruction. In the table of this latter test there is first a column of actual pressure, and then a column of estimated pressures, which would have strained the full original thread to the same extent. This latter column I have added to show the full strength of the respective plugs in comparison to that of the gun as expressed in pressure per square inch in powder chamber. The table will show some upsetting of the threads of both plugs early in the test. This I consider due to unavoidable imperfection in workmanship, such as roughness of surfaces, and an inaccurate fit. The elastic strength of the gun under hydraulic pressure is about 40000, while that of the cylindrical plug seems to be about 60000, and that of the conical plug is between 70000 and 80000. The superiority of the conical plug is due to its greater threaded area. The greater ultimate strength of the cylindrical plug (125,000 as against 110,000 for the conical plug) is not very important, as no gun, (certainly not a light gun like the 5-inch Army gun) could be subjected to a pressure of over 100,000 pounds per square inch without bursting, and the cylindrical plug was made useless under a pressure which the conical plug stood without having its quality of ease of opening and closing materially impaired.

It should further be remembered that the threaded portion engaged on the conical plug weighs about 53 pounds while the corresponding part ot the cylindrical plug weighs 74 pounds and that consequently, weight for weight, the conical plug has 12 per cent greater ultimate strength. and fully 70 per cent greater elastic strength than the cylindrical plug.

Yours truly,

J. F. Meigs.

ACCOMPANYING SHEET I, REPORT OF FEBRUARY 1900.



HOUSINGS AND BLOCKS BEFORE TESTING.

BETHLEHEM STEEL COMPANY.

SHEET I, FEBRUARY, 1900

TEST OF CONICAL AND CYLINDRICAL BREECH BLOCKS. (Threads Complete.)

Threaded Area of Conical Block 93 Square Inches.
Threaded Area of Cylindrical Block 66 Square Inches.

Weight of Threaded Portion of Conical Block, 53 Pounds.
Weight of Threaded Portion of Cylindrical Block, 74 Pounds.

	Pressure	Powder Chamber			Housing		Distance from bottom of rearmost thread of Plug to tops of threads so selected as to show effect of Compression of Plug. Given in inches.				REMARKS.
		Inside Diameter		Length Between Points	Enlargement of Outside Diameter						
		Rear	Front		During Pressure	After Pressure	1	2	3	4	
CONICAL PLUG.	0	5.505	5.5005	1.28		0	3.561				Plug screwed home to a stop.
	30000	5.505	5.5005	1.28	0.001	0	3.564				Thread bent on account of inaccuracy in cutting.
	40000	5.5055	5 501	1.28	0.002	0	3 565				The same.
	45000	5.5075	5.5035	1.28			3.565				Opened with some difficulty.
	32500	5.5075	5.5035	1.28			3.565				Plug in this and following tests screwed home to within 6° of a stop. No sticking.
	35000	5.5075	5.5035	1.28	0.0015	0	3.565				Opened with great ease.
	37500	5.5075	5.5035	1.28			3.565				Opened with great ease.
	54000	5.5085	5.5055	1.2825			3.565				Opened with great ease. Plug marked by gas check ring.
CYLINDRICAL PLUG.	0	5.4975	5.4995	1.28			4.739	3.748	2.754		
	30000	5.4975	5.4995	1.28	0.001	0	4.739	3.748	2.754		
	35000	5.4975	5.5000	1.28	0.0015	0	4.739	3.749	2.755		
	30000	5.4975	5.5000	1.28	0.001	0	4.740	3.749	2.756		
	37500	5.4975	5.5000	1.28	0.00175	0					
	40000	5 4980	5.5010	1.28	0.002	0	4.741	3.749	2.756		
	45000	5.5005	5 5025	1 28	0.0023	0	4.744	3.749	2.757		Opened with some difficulty.
	50000	5.5010	5.5027	1 282	0.0025	0	4.745	3.751	2.757		Opened with some difficulty.
	54000	5.5025	5.5040	1.2825			4.745	3.752	2.757		Opened with some difficulty.

BETHLEHEM STEEL COMPANY.

SHEET II, FEBRUARY, 1900

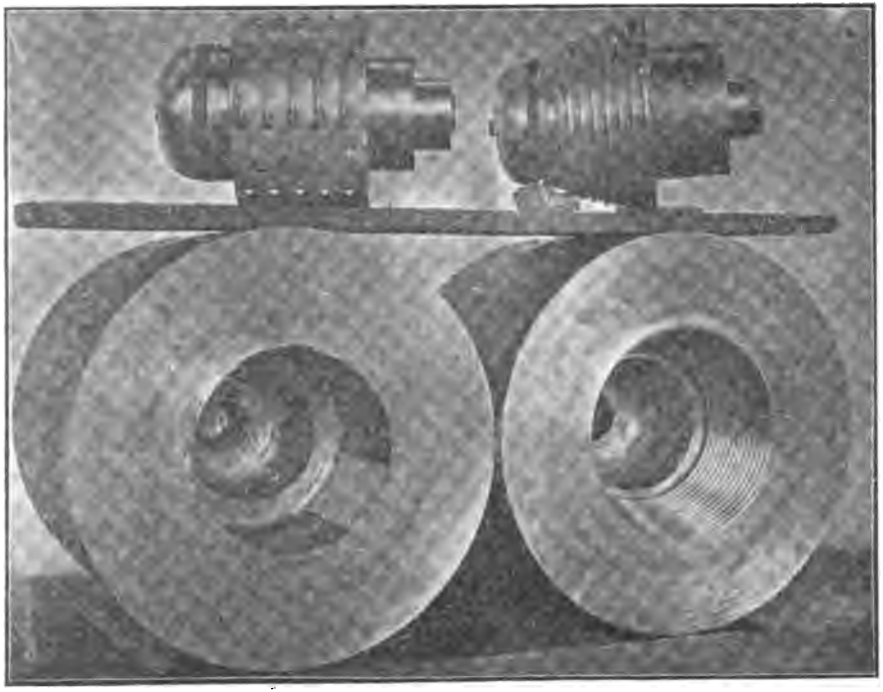
TEST OF CONICAL AND CYLINDRICAL BREECH BLOCKS. (One Half of Threads Removed.)

Threaded Area of Conical Block, 46.5 Square Inches.
Threaded Area of Cylindrical Block, 33 Square Inches.

Weight of Threaded Portion of Conical Block, 53 Pounds.
Weight of Threaded Portion of Cylindrical Block, 74 Pounds.

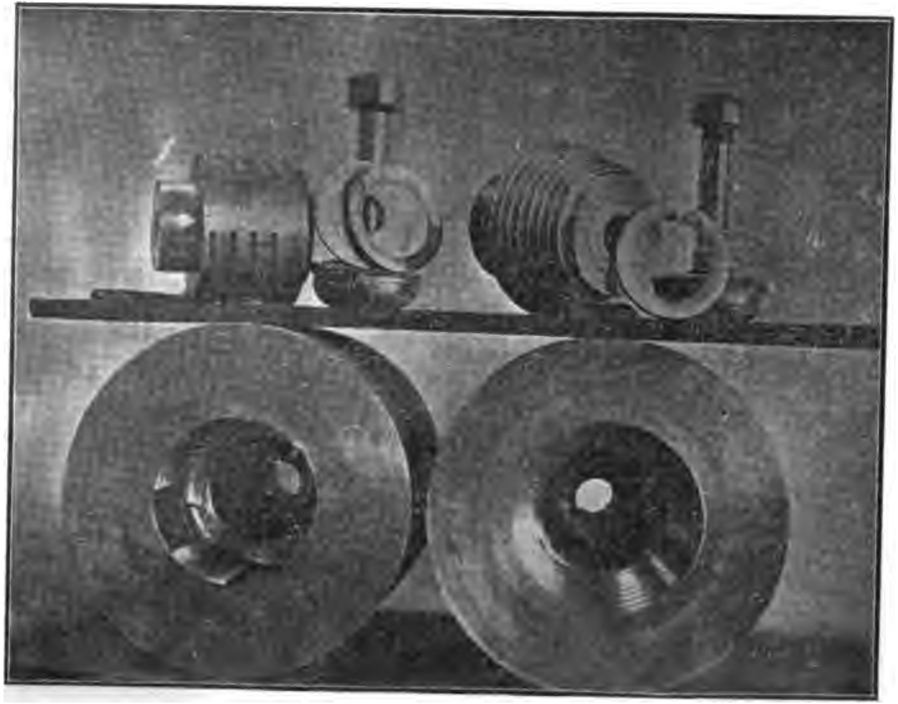
	Pressure		Powder Chamber			Distance from bottom of rearmost thread of plug to top of threads so selected as to show effect of compression of plug. Given in inches.				REMARKS.
	Actual	Corresponding to full Area of Threads	Inside Diameter Front	Inside Diameter Back	Length Between Points	1	2	3	4	
CONICAL PLUG.	0	0				3.565	2.420	1.272		Opened with great ease.
	30000	60000				3.565	2.420	1.272		Opened with great ease.
	35000	70009				3.565	2.420	1.272		Opened with great ease.
	40000	80000				3.566	2.420	1.274		Opened with great ease.
	45000	90000				3.572	2.425	1.280		Opened with ease.
	50000	100000				3.578	2.433	1.288		Opened with some difficulty.
	55000	110000	5.5100	5.5065		Threads destroyed in Gun by shearing.				Opened with great difficulty, circumference of screw forced 0.01'' to the rear.
CYLINDRICAL PLUG.	0	0				4.263	3.261	2.269	1.265	New threads marked.
	30000	60000				4.265	3.261	2.269	1.265	Opened with difficulty.
	35000	70000				4.266	3.263	2.271	1.268	Opened with difficulty.
	40000	80000				4.267	3.266	2.271	1.268	Opened with difficulty.
	43000	86000				4.271	3.270	2.277	1.271	Opened with increasing difficulty as the tests became more severe.
	48000	96000				4.276	3.274	2.280	1.272	Threaded sectors forced 0.015'' to the rear.
	52000	104000				4.293	3.288	2.292	1.285	Threaded sectors forced 0.02'' to the rear.
	58000	116000				Plug forced 0.1 inch to the rear.				Threaded sectors forced 0.035'' to the rear.
	62500	125000	5.506	5.509		Thread in gun and plug destroyed by bending				Rear gas check ring spread, forcing itself into the gas check seat.

Accompanying Sheet II, Report of February 1900.



HOUSINGS AND BLOCKS AFTER TEST WITH FULL THREAD ON BLOCKS.
(Blocks with one half thread cut away.)

ACCOMPANYING SHEET II, REPORT OF FEBRUARY 1900.



HOUSINGS AND BLOCKS AFTER TESTING.
(Blocks dismounted showing effects of test.)

Report of Artillery Inspector, Department of the East.

HEADQUARTERS DEPARTMENT OF THE EAST,
OFFICE OF ARTILLERY INSPECTOR,
Governor's Island, N. Y. City, July 30, 1901.

The Adjutant General,
Headquarters Department of the East,
Governor's Island, N. Y.

SIR:

In compliance with your letter of the 1st instant, I have the honor to submit the following report as the Inspector of Artillery of the Department:

The artillery after many years of persistent effort and patient waiting has realized its just aspirations by its organization into a corps with a chief of artillery.

The regulations defining the duties of the chief clearly show the great importance of the work devolving upon him, and it is to be regretted that the Congress did not invest the office of chief of artillery with a rank adequate to its dignity and responsibility.

The Act of February 2, increasing the efficiency of the army charged the coast artillery with the care and use of the fixed and movable elements of land and coast fortifications including the submarine mines and torpedo defenses. Under this legislation the torpedoes, mining casemates, and mining material in all our harbors have been, or will soon be, turned over by the engineers to the artillery.

The most important problem now pressing upon the artillery is how to provide a sufficient number of officers and men qualified to operate the mining defenses of our harbor. It is admitted that the present established strength of the coast artillery will not furnish one relief for the modern armament already provided, and that in the event of war the deficiency must be supplied by raw recruits or by volunteer artillery. If war were to occur with a superior naval power, an immediate dash would no doubt be made upon one or more of our most important ports. To oppose such an attack we should have an instructed force of sufficient strength to execute, in less than one week after the declaration of war, the approved project for the planting of mines in all our harbors.

To operate these mines in the harbors of the United States and of its distant possessions will require about 70 officers and 2,700 soldiers. At the time of the immediate planting an addition of 5,000 men as laborers and boat crews will be temporarily needed. All officers employed on this work ought to be experts in electricity.

With respect to the officers now being appoinred to the artillery from the army, their examination for appointment does not include even an elémentary knowledge of electricity, and it is probable that few, if any of them, will ever be qualified for this work. Again, the required number of officers is so large that they could not all be spared for this duty without seriously crippling the artillery, in the service of the armament. In our late war with Spain the deficiency in officers of engineers for mining work was supplied by civilian experts in electricity. Civilians cannot be held to service, or to punishment for malfeasance, and some scheme should be devised by which all our mining defenses may be efficiently operated in time of hostilities by military organizations. If a sufficient permanent establishment cannot be supplied for this purpose then a volunteer reserve must be organized and officered by electrical engineers—graduates of technical schools. This appears to be the only feasible plan of securing enough officers for this special service sufficiently qualified for the work. The advisability of creating volunteer organizations for mining service should receive early consideration.

The first step that should be taken with the least practicable delay is the establishment of an Artillery School of Mines for theoretical and practical instruction. To this school, in my judgment, ought to be attached the School for Electrician Sergeants, now at Fort Monroe, Va.

Mining material is now, in general, cared for by civilians paid from the appropriations of the engineer department. It would be much more economical and probably more efficient if these civilians were replaced by electrician sergeants, and it is recommended that one electrician sergeant be authorized by law for each harbor of the United States equipped with mining material.

Whenever a small arm is to be adopted in the infantry service, it has been the wise custom to have a board including infantry officers to determine the special arm to be selected. It is certainly of equal or greater importance that the artillery should have a voice in the choice and selection of guns, carriages and other material for that branch of the service, yet it is the fact that the artillery has not been consulted as to the adoption of any type of gun or carriage with which they are expected to serve or fight. The mere statement of these facts is convincing that there should be a change in our practice which is contrary to the practice of the leading military nations of the world. To effect this reform, the artillery should be represented on the Board for Testing Rifled Cannon as established by law, by at least two members. The artillery ought also to be represented at the Sandy Hook Proving Ground where all guns, carriages, ammunition and other material for the coast artillery are tested. These details to represent the artillery should be in addition to the details of officers for ordnance duty, authorized by recent legislation. Field artillery with its material ought first to be tested at the Sandy Hook Proving Ground for strength of construction, in the usual proof and ballistic trials, and again fully tested under service conditions, as near as may be, at the Field Artillery School, Fort Riley, Kansas, before adoption into the service.

The initiative of the present Chief of Enginesrs in having an artillery officer appointed as a member of the Board of Engineers to participate in its deliberations. and in the determination of the fortifications and armament best adapted to the coast defence is in pleasing and marked contrast to the attitude of the ordnance department to the artillery corps.

It is very desirable that an insensitive high explosive should be found capable of being fired through heavy armor without exploding, and it is understood that gratifying progress is being made in that direction.

During the active practice season at fortifications where more than one company or battery of artillery are present, all details which separate a soldier from his company should be suspended for at least one calendar month, so that at all drills, all men of the company except the guard and sick shall be present. During the target practice all men of the company except the sick should be present.

Cavalry and infantry have a band for each regiment; our artillery has a strength of officers and men which represents thirteen regiments organized as are the infantry and cavalry, but of greater aggregate strength, and for these there should be thirteen bands, but only ten are now authorized by law. It is recommended that efforts be made to obtain by legislation three additional bands. All artillery bands should be assigned to the headquarters of artillery districts.

At the present there are, at each artillery post, an ordnance officer, an engineer officer, and a signal officer responsible for the properties of the respective departments at the post, who make separate requisitions for stores on the respective bureaux, keep the property in separate storehouses, and make separate property returns. Although this property is all needed in artillery equipment it requires an expert to know the exact limits of the stores to be supplied by each bureau. The same tool, if used for two separate purposes, may be sapplied by two of the bureaux, and it has happened that an indispensable article could not be obtained because it was on no regular supply table—a worship of bones to the starving of flesh.

In the matter of the installation of a fire control system, property from all three of these departments has to be used. There is no particular co-ordination between the departments and any two might supply all that would be necessary for a fire control system at a post and yet such system not be completed because a third department might be unable to furnish the additional material needed.

Moreover, by reason of the turning over of mining material to the artillery, there is another kind of property which may be called artillery property, and for which as yet no rules have been made with respect to returns.

The statements just made show how desirable it would be to have but a single supply bureau to furnish all the artillery equipment needed at posts,—this can only be accomplished by legislation, or if legislation be impracticable there should be a depot from which all stores requised to equip the artillery might be issued—this can be accomplished by executive order. A more unmethodical and uneconomical way of transacting public business than the present system with its resultant confusion, cannot be imagined. To unify and simplify the work now imposed upon officers responsible for artillery property is a reform that should be earnestly striven for.

It is gratifying to annouuce that the preparations for the test of mortars in Portland Harbor, Me., under the general direction of the Board of Ordnance and Fortification, and subject to the prescribed conditions of fire control and direction, are making satisfactory progress, and it is confidently expected that the trials will take place within the next month or two.

It is with regret it is stated that on account of the paucity of officers it will be impossible this year to have the tests at Fort Wadsworth, N. Y., which were intended to determine not only the relative merits, in a system of fire control and direction, of position finders with a horizontal base and of those with a vertical base, but the value of electric search lights in the defense of harbors against attack by enemy's vessels. It is very unfortunate that the test could not have been brought to a successful conclusion this year.

There is a general agreement umong the artillery officers who have given the most time and study to the subject of fire control that no single system of position finding should, in the present state of artillery progress, be adopted for use at all posts; the natural elevation of the ground at the forts will determine whether the vertical position finder or the horizontal position finder should be preferred. Heretore the only board of officers charged with the consideration of this subject was directed to locate and definitely fix sites for the depression position finder. That board had no authority to consider or recommend the method ot position finding best adapted to the topography of the posts visited by it. A board of officers should formulate the principles which ought to determine the special type of position finder adapted to each coast fortification, and, these principlee being approved, in order to have a uniform system at all the fortifications, one board ought to fix the system best adapted to the local conditions to be installed at each fort.

The construction of quarters and the acquirement of the necessary land for the location of quarters at the new artillery posts in this department have not made satisfactory progress during the last year. This unsatisfactory condition has existed for three years, and has been mentioned in my previous annual reports. It is interesting to contrast the actual condition of the new artillery posts in this department with the army regulation respecting reservations, "military posts, stations, and reservations having been selected for occupation by the military forces, not only for immediate and temporary use, but in most cases for occupation so long as the Government shall exist, department and post commanders are required to see that every consideration is given to their care, preservation, and adornment. They will not only be made useful and healthful to the garrisons, but be made attractive homes for the Army by every means available for that purpose * * * * ."

The enlisted strength of the artillery exceeds one-fourth of the established enlisted strength of the line of the army, yet with six major generals, and fifteen brigadier generals in the line of the army, there is only one—a brigadier general—who has been in the artillery, but at the time of his appointment, it was stated in the daily press that his promotion was due solely to his services in the volunteer infantry, in other words he is not to be credited to the artillery. Is it to be accepted that no service however meritorious, if confined to the artillery, shall be rewarded by promotion to the grade of general officer? This discrimination against the artillery has existed in our army ever since the end of the Civil War in 1865, and it will only be by united effort on the part of artillery officers that a change for the better can be effected.

In many of the foreign services there are artillery generals of different grades, whose services are confined to their own corps. If in our army recognition for artillery service can be obtained in no other way, an endeavor should be made to have a proportionate share of general officers appointed in the artillery corps solely for artillery service.

It is not known that any progress has been made in providing auto-sights for the rapid fire guns of our coast defence. These sights have received so much commendation from some military authorities abroad that early steps ought to be taken for their trial to determine their value for adoption into our service for rapid fire guns.

It is recognized that the present established strength of the coast artillery is not sufficient to furnish one relief for the armament already provided. This deficiency in time of war can only be met in two ways; one by increasing the enlisted strength of the companies with recruits without previous instruction, or by accepting into the United States service, volunteers organized in time of peace as artillery of the National Guard of the several states. The regular artillery will gladly welcome any volunteer force which can come into the service qualified for efficient work. It will be admitted at once that the militia private readily learns to serve the piece, which simply involves intelligent manual labor.

The non-commissioned officers, who act as gunners and gun commanders, or who are liable to other details pertaining to their grade, should have a practical knowledge of angle measuring instruments, the use of plotting boards, knowledge of sights and qnadrants, the aiming and laying of guns, preparation of fuzes and ammunition, the use of difference charts and gun commander's range scales. These qualifications are only a part of the course required of "gunners" in the regular artillery, and can be readily acquired with sufficient application by an intelligent national guardsman; the appointment of non-commissioned officers in the regular artillery is, as a rule, confined to gunners, and non-commissioned officers in volunteer artillery should have similar qualifications if they are expected to be efficient in their special duties.

In modern artillery with its elaborate and complex system of fire control and direction, the effectiveness of fire depends upon the efficiency of the officers; the responsibility of the enlisted man is much diminished, and of the officers much magnified. In the artillery the higher the rank, the more complicated and responsible are the duties. Due to this condition, the weakest point of a militia artillery organization is its officers, yet it is not altogether the fault of the officers that they are not efficient; to become so they need long and continued training, for which in most cases, they can ill afford to spare the time, and whenever given is, in general, at a great personal sacrifice.

During our late war with Spain individual companies of a certain volunteer artillery regiment were stationed at forts, while the field officers and their staff were either encamped beyond the sound of the guns, or stationed where they could not have command. This militia regiment had been organized as artillery for some ten years, and for a part of the time one of our most earnest and efficient artillery officers had been especially assigned to its instruction. In 1898 it was generally recognized as the most efficient volunteer artillery regiment in the country, yet its senior officers were not, in the hour of war, assigned to the modern armament with command adequate to their rank. Any plan of organization which, in the event of hostilities, must sequester its superior officers is not to be wholly commended.

In Great Britain as with us, the regular artillery is insufficient, and this deficiency is supplemented by volunteer artillery organizations which are borne on the army lists with the regular artillery; much care and attention have been devoted to their instruction, and it has generally been assumed, especially in this country, where little is known of them beyond their name, that they have proved the value of such artillery.

In a recent English journal discussing the subject of "Volunteer Efficiency," I find this comment;

> "In one corps only 6 officers out of 27 have passed either the school of instruction or the artillery examination; in another 6 out of 25, in others 6 out of 16, 6 out of 14, 10 out of 26, 4 out of 11, 8 out of 16, 15 out of 37, and 18 out of 23; in one corps the major four captains and six lieutenants have not apparently passed the examination."

If militia artillery are to be of any use to the United States, they are worth paying for by the United States; if they are of no use, they ought not to be counted in our resources of military strength.

The following suggestion is offered. Militia organizations of artillery shall go into camp yearly for a specified number of days. While in camp the officers and men shall receive pay from the United States. During the encampment soldiers and officers shall be under the observation and inspection of regular artillery officers and upon the report of these officers the Secretary of War will decide if the organization shall be encamped the ensuing year. By this means the War Department will have a sufficient record as to the measure of efficiency of these troops if they are needed for active service.

The regular artillery will give a cordial co-operation to any scheme which will provide an efficient auxiliary force as a reserve to be called into service in time of war.

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Very respectfully,
Your obedient servant,
J. P. STORY,
Lieutenant Colonel Artillery Corps.
Artillery Inspector.

BOOK REVIEWS.

Reflections on the Art of War. Major-General Sir Reginald Clare Hart, V. C., K. C. B., commanding a first-class district in India. Third edition. London: William Clowes and Sons, Limited. 1901. Pp. 364. Price 7/6.

General Hart, V. C., the author of this interesting and useful volume, is an Indian officer of high standing, and commanded a brigade in the recent Tirah campaign. He has gained his knowledge and experience in the field practically, as well as by careful study theoretically, and his present work is mainly a compilation of notes which he made for his own instruction.

His aim has been to avoid the dry recital of the principles of the art of war, and to teach these principles in a discussive and entertaining way, so that his readers may, almost without knowing it, gradually aquire a knowledge of the theory of war, and cultivate a taste for military literature.

The opening chapter is of a general character, and discusses the high qualification required in great generals, the rest of the work treats of the principles of strategy and tactics in proper order, closing with an entirely new chapter (in this third edition) on mountain warfare, which is of such great importance in northern India.

The chapters on *strategy* comprise the theory and practice of war, the fortune of war, moral effect in war, the offensive and defensive, and pursuits. Those on *tactics* discuss the subjects of advance and rear guards, the selection of positions, the effect of modern fire-arms, outposts, marches and night operations, besides containing seperate chapters on the arms of cavalry, artillery and engineers, and an essay on sanitation. Throughout the work references are made to the works of the accepted authorities on the subjects considered, and the text is interspersed with many quotations.

The Art of War has had many and able exponents, yet it is an Art so many-sided, so susceptible of infinite modification, according to time, place and circumstance, and, above all, according to the capacity and temperament of those who conduct it, that fresh contributions to its study are still acceptable, and herein lies the reason for the appearance of the present work, and its sufficient excuse. It is pleasant and attractive reading, and cannot fail to interest and hold the attention of the officers for whose benefit it was written, and in this way it will fulfill its mission.

The publishers have done their share to make the volume a handy one for use, and pleasing and attractive to the eye. J. P. W.

All the World's Fighting Ships. Fred. T. Jane. 1901. New York City: Harper and Brothers, Ltd.

This cosmopolitan naval annual, now in its fourth year of issue, has become indispensable to the navies and the coast artilleries of the world as a work of reference.

This edition, besides being much larger than any previous issue, also embodies great changes in arrangement, and considerable attention is bestowed on the silhouettes of the ships, which show starboard as well as port side now. The larger of these silhouettes are all drawn to scale and give the ship as she appears to the naked eye at about 4000 yards; the smaller ones give her appearance at greater distances.

The arrangement of the ships of the different nations has been entirely changed, so that they now stand in the order of fighting value under each nation. There is now a plan and elevation of every single fighting ship in the world, and, so far as possible, plans, too, of all destroyers and torpedo craft, all on one uniform scale.

A second part has been added this year, viz: articles on the great naval questions of the day, submarines, battleships and gunnery, which will prove of immense interest and value.

At the end of the book is a silhouette index of warships, and another of merchant ships available for war purposes, by means of which in time of war any ship of the enemy may be readily identified.

Since its first appearance four years ago this work has made its influence felt, and now it is practically indispensable. Every ship and coast fort should be kept supplied with copies of the latest edition, and constant practice in maneuvers and in coast artillery problems should be had with it.

The illustrations are all excellent, and no pains have been spared to make them accurate and full. J. P. W.

Official Crests of the British Army now in daily use. London and Aldershot: Gale and Polden, Ltd. Price, Two shillings and sixpence.

A pamphlet containing 240 beautiful designs in color, including all regimental badges. The history of the British Army is interesting to us all, and that of most of the separate regiments is part of the world's history and of English literature.

Anwendung der Elektrischen Momentphotographie auf die Untersuchung von Schusswaffen. Professor Dr. Carl Cranz. Halle a. S.: Verlag von Wilhelm Knapp. 1901.

Professor Cranz, the able and energetic investigator of the ballistics of small-arms by means of instantaneous photography, has added another to his classic studies. The present pamphlet, after a brief account of the history of such investigations, recounts a series of experiments with the Mauser automatic pistol, illustrated by twenty-four photographs taken consecutively during firing.

The questions to be solved are several: the relative actions of the mechanism and the flight of the projectile, whether the block is gas tight or not, and the actual times consumed in the various operations of the mechanism, finally, whether the gases in front of the projectile as it leaves the bore are the air previously in the bore or are powder gases.

The experiments have been carefully conducted, and the reasoning is simple and clear. The work is worthy of careful study by all interested in ballistics, and constitutes a most valuable addition to the literature of the subject.

J. P. W.

Views of Woolwich and Royal Military Academy. Aldershot and London: Gale and Polden, Ltd. Price 1 shilling.

This pamphlet is a photographic album of the Woolwich District and the Royal Military Academy, illustrating the most important parts of the town and barracks, with snapshots of cadets training at the Academy.

The pictures give one an excellent idea of the great national Arsenal of England, and of the famous military school where so many of the officers of the Royal Artillery received their education and training.

Photograghic Views of Eton College. London and Aldershot: Gale and Polden, Ltd. Price 1 shilling.

A photographic album of Eton College, with illustrations of the exteriors and interiors of the College buildings, and snapshots of the students at sport and study.

The views present picturesque old Eton (founded about 460 years ago) and its college life as it is today. J. P. W.

Durchfuehrung des Artilleristischen Aufklaerungsdienstes. Gustav Smekal, k. u. k. Major des Generalstabs-Corps. Vienna: L. W. Seidel and Sohn. 1901. Pp. 121. 5 marks.

This work is a continuation of the author's previous study of *Field Artillery Reconnoissance*, and discusses the subject as applied to a particular case of such duty, solving the problems that arose in the former work, and discussing these solutions.

The general problem considers an infantry division in pursuit, and the special problems take up the duties of the divisional artillery, especially in effecting its own reconnoissance. The latter are formulated after the usual method employed in setting and solving such problems, and go into great detail.

The necessity for field artillery to make its own reconnoissance has been apparent for some time, but has been particularly emphasized by the experiences of the British in South Africa.

These studies are most valuable aids to acquire a clear conception of modern field duty, and constitute the best means of acquiring a good working knowledge of field artillery tactics.

The work is illustrated by 15 maps and sketches, and will interest all field artillery officers and repay them for the time they may devote to its study.

J. P. W.

Die Theorie des Schissens. Heinrich Goepp, k. u. k. Hauptmann im Infanterie-Regimente Nr. 50. 2nd Edition. Vienna: L. W. Seidel & Sohn. Pp. 51. 2.40 marks.

The author here presents explanations of two important sections in the infantry *Firing Regulations*, one relating to the fire of the individual infantry soldier, the other to that of the squad or section.

It is, in reality, a treatise on target practice and skirmish fire, considering not only the principles of the trajectory, the use of the sight, its graduation and adjustment, and the dispersion of the shots, but also the effective fire zones, the regulation and control of fire, the admissible errors at different ranges and the effect of the terrain on the establishment of the fork for squad or section fire.

The work as a whole is a thorough study of the theory of infantry fire in actual combat, and should be carefully studied by soldiers of all arms, but more especially by the infantry. J. P. W.

Alloys of Iron and Nickel. R. A. Hadfield. Excerpt Minutes of Proceedings of The Institution of Civil Engineers. London: Published by the Institution. Great George Street, Westminster, S. W. Pp. 171.

The author, well known as an authority on steel in all its forms, here presents views and data of particular value to the Ordnance and Artillery, in that guns, armor and projectiles, are concerned.

The subject is introduced by a brief discussion of the physical properties of iron and nickel alone, and of their combinations, or iron-nickel alloys, passing thus to nickel steel and its uses, the important part of the paper. An appendix gives the early history of nickel, its compounds, its ores and their reduction; other appendixes give data on nickel and iron alloys, principally in the form of very complete and extended tables.

The work is a most thorough discussion of the subject, and a valuable addition to its literature. J. P. W.

Studien ueber Kriegfuehrung auf Grundlage des Nordamerikanischen Sezessionskrieges in Virginien. Freiherrn v. Freytag-Loringhoven, Major im Grossen Generalstabe. Zweites Heft. Berlin: E. S. Mittler und Sohn. 1901. Pp. 146. 4 Marks.

These studies in strategy are based on the Civil War in the United States, especially the campaigns in Virginia. This, the second of the series of pamphlets, comprises the campaign in Maryland (Antietam) and the campaigns of Fredericksburg, Chancellorsville and Gettysburg.

Lee's offensive advance into Maryland is compared with Napoleon's campaign of 1813, around Dresden-Leipzig, and in the Fredericksburg campaign the tactics and strategy are discussed in the light of Napoleon's methods and maxims. Chancellorsville is contrasted with the battle of Torgau in 1760, the last great offensive battle of Frederick the Great. Finally, Gettysburg finds its counterpart (in part at least) in several battles of 1870–1, namely Metz and Sedan, and in Napoleon's 1807 campaign against the Russians.

The work is particularly interesting to us as a study in strategy, and as a foreign, unbiassed discussion of the work of the Union and Confederate generals. It is illustrated by four large outline maps and by fourteen sketches in the text. J. P. W.

BOOK NOTICES.

[These books will be fully *reviewed* as space becomes available.]

The contents of **The Popular Science Monthly** for November, apart from reviews, discussions and notes, are:

On The Tendency of Species to Form Varieties, Charles Darvin and Alfred Wallace; The Story of Cahow, Professor A. E. Verrill; Psychiatry—Ancient, Medieval and Modern, Dr. Frederick Lyman Hills; The National Control of Education, Sir John E. Gorst; The Evolution of the Human Intellect, Professor Edward L. Thorndike; The Origin of Sex in Plant, Dr. Bradley Moore Davis; The Fishes of Japan, President David Starr Jordan; The Omen Animals of Sarawak, A. C. Haddon, F.R.S.

The Popular Science Monthly for November, opening the sixtieth volume, gives the first place to a reproduction of the first announcement of the theory of evolution by natural selection made by Darwin and Wallace before the Linnean Society in 1858. The original is quite inaccessible, and it is of much interest to see the way in which this great theory was presented by the two men who independently proposed it. Other articles in the number are an illustrated account by Professor A. E. Verrill of the Cahow, an extinct bird of the Bermudas; a description by Dr. F. L. Hills of the way the insane were treated formerly compared with present methods; a discussion of the part that should be taken by the nation in the control of education by Sir John Gorst; a comparison of the intellect of man with that of the lower animals by Professor E. L. Thorndike; an explanation of the origin of sex in plants by Dr. B. M. Davis; a description of the omen animals of the South Sea Islands by Dr. A. C. Haddon, and an account of the fishes of Japan by President David Starr Jordan of Stanford University.

INDEX TO CURRENT ARTILLERY LITERATURE.

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The German expeditionary Corps for China.—**Jour. U. S. I., India**, April.

Maxim gun transport in China.—**Jour. U. S. I., India**, April.

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Changes in the world's armies.—**Jour. R. U. S. I.**, August; **Cercle**, August 31–September 28; **Int. Rev.**, October.

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Field engineers in war.—**R. Mil., Brazil**, August.

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Battalion organization and battle training.—**Unit. Serv. Mag.**, September.

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